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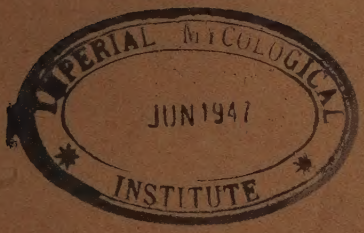


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*MATHÉMATIQUES*

# SUR LES CRITÈRES POUR QU'UN SYSTÈME DE FONCTIONS ANALYTIQUES SOIT COMPLET

Par A. MARKOUCHEVITCH

*(Présenté par S. L. Soboleff, de l'Académie, le 4.X.1943)*

1. L'objet de cette Note est le problème suivant:

Soit $\{f_n(z)\}$ un système de fonctions analytiques dans le cercle unitaire. Trouver des conditions pour que ce système soit complet en ce sens que pour chaque fonction $f(z)$ analytique dans le cercle unitaire et pour $\varepsilon$ et $r$ arbitraires, pourvu que $0<\varepsilon$ et $0<r<1$, il existe un polynôme $P(z)$ par rapport aux fonctions $\{f_n(z)\}$, soit $P(z)=\sum_0^n c_j f_j(z)$, tel que pour $|z|\leqslant r$ on a l'inégalité

$$|f(z)-P(z)|<\varepsilon.$$

2. Le théorème qui suit donne un critère nécessaire et suffisant pour que le système des fonctions $\{f_n(z)\}$ soit complet.

Théorème I. *Pour que le système des fonctions $\{f_n(z)\}$ analytiques dans le cercle unitaire soit complet dans ce cercle, il faut et il suffit que pour une fonction quelconque $F(z)=\sum_0^\infty A_n z^n$ analytique dans le cercle unitaire et pour laquelle $A_n\neq 0$ $(n=0,\ 1,\ 2,\ \ldots)$ on a une relation de la forme*

$$\frac{1}{\zeta}F\left(\frac{z}{\zeta}\right)=\sum_0^\infty \varphi_n(\zeta)\{A_0^{(n)}f_0(z)+\ldots+A_n^{(n)}f_n(z)\} \qquad (1)$$

*où les $\{\varphi_n(\zeta)\}$ sont des fonctions analytiques dans le domaine $|\zeta|>r$, $r<1$, et la série converge uniformément pour $|z|\leqslant\rho$, $|\zeta|\geqslant\rho'>\max(r,\rho)$, quels que soient $\rho$, $\rho'$ tels que $0<\rho<1$ et $\rho'>\max(r,\rho)$.*

3. Remarquons que si dans les conditions du théorème précédent on suppose encore que la limite $\lim_{n\to\infty}\sqrt[n]{|A_n|}$ existe et qu'elle est égale à 1, on trouvera, en posant pour abréger $A_0^{(n)}f_0(z)+\ldots+A_n^{(n)}f_n(z)=P_n(z)$, que chaque fonction $f(z)=\sum_0^\infty a_n z^n$ analytique dans le cercle unitaire est représentée dans ce cercle par la série

$$f(z)=\sum_0^\infty \alpha_n P_n(z) \qquad (2)$$

où

$$a_n = \frac{1}{2\pi i} \int_{|\zeta|=\rho'} \tilde{f}(\zeta)\, \varphi_n(\zeta)\, d\zeta \quad (r < \rho' < 1)$$

et

$$\tilde{f}(\zeta) = \sum_0^\infty \frac{a_n}{A_n} \zeta^n. \tag{3}$$

4. Le théorème suivant donne un critère pour qu'un système soit complet, critère qu'il est facile à appliquer.

Théorème II. *Soit $\Psi(z, \zeta)$ une fonction de deux variables, analytique par rapport à z pour $|z| < 1$ et pour chaque $\zeta$ fixe, $|\zeta| < R$, et analytique par rapport à $\zeta$ pour $|\zeta| < R$ et pour chaque z fixe, $|z| < 1$. Supposons que l'une des deux conditions est remplie:*

a) *le système des fonctions*

$$\left\{ \left[ \frac{\partial^n \Psi(z, \zeta)}{\partial \zeta^n} \right]_{\zeta=0} \right\} \tag{4}$$

*est complet dans le cercle unitaire, ou bien*

a') *le système des fonctions*

$$\{\Psi(z, \zeta^n)\}, \quad |\zeta^{(n)}| < R \tag{5}$$

*est complet dans le cercle unitaire.*

*Supposons enfin que pour chaque fonction réelle $h(\theta)$ à carré sommable dans l'intervalle $(0, 2\pi)$ et pour une suite de points $\{\zeta_n\}$, $|\zeta_n| < R$, la condition suivante est vérifiée:*

b) *si la fonction analytique $\Phi(\zeta) = \frac{1}{2\pi} \int_0^{2\pi} h(\theta)\, \Psi(re^{i\theta}, \zeta)\, d\theta$ $(0 < r < 1, r$ fixe$)$ s'annule aux points $\zeta_n$, elle est identiquement nulle.*

*Alors le système des fonctions*

$$\{\Psi(z, \zeta_n)\} \tag{6}$$

*est complet dans le cercle unitaire.*

Ce théorème permet de conclure que le système (6) est complet si l'on sait que le système (4) ou (5) est complet. Le principe qui est la base de ce théorème n'est pas nouveau. C'est T. Carleman (1) qui l'a appliqué le premier dans les problèmes concernant les systèmes complets*.

5. Soit $F(z) = \sum_0^\infty A_n z^n$ une fonction entière pour laquelle $A \neq 0$ $(n = 0, 1, 2, \ldots)$. En posant $\Psi(z, \zeta) = \sum_0^\infty A_n z^n \zeta^n$ et en remarquant que le système $\left[ \frac{\partial^n \Psi(z, \zeta)}{\partial \zeta^n} \right]_{z=0} = n!\, A_n z^n$ est complet dans ce cercle unitaire [condition a) du théorème II] on obtient comme conséquences immédiates du théorème II les propositions suivantes.

Théorème III. *Si $\{\zeta_n\}$ est une suite de nombres complexes différents telle que $|\zeta_n| \leqslant |\zeta_{n+1}|$ et*

$$\overline{\lim_{n \to \infty}} \frac{\ln n}{\ln |\zeta_n|} = \mu > 0 \tag{7}$$

* B. J. Levine m'a communiqué qu'il a aussi obtenu un critère exprimé par le théorème II et que parmi les applications diverses de ce critère dont il continue à s'occuper, il a aussi trouvé les théorèmes III, IV, V et VI.

($\mu$ *étant l'exposant de convergence des nombres* $|\zeta_n|$), *et si* $F(z)=\sum_0^\infty A_n z^n$ $(A_n \neq 0,\ n=0,\ 1,\ 2,\ \ldots)$ *est une fonction entière d'ordre* $\rho<\mu$, *alors le système* $\{F(z\zeta_n)\}$ *est complet dans le cercle unitaire.*

Théorème IV. *Si pour les nombres* $\{\zeta_n\}$, *on a non seulement la condition* (7), *mais encore la condition*

$$\overline{\lim_{n\to\infty}} \frac{n}{|\zeta_n|^\mu} = \nu > 0 \tag{8}$$

*et si*

$$F(z)=\sum_0^\infty A_n z^n \quad (A_n \neq 0,\ n=0,\ 1,\ 2,\ \ldots)$$

*est une fonction entière d'ordre* $\rho=\mu$ *et du type* $\sigma<\frac{\nu}{e\mu}$, *alors le système des fonctions* $\{F(z\zeta_n)\}$ *est complet dans le cercle unitaire.*

Théorème V. *Soit* $F(z)=\sum_0^\infty A_n z^n (A_n \neq 0,\ n=0, 1, 2, \ldots)$ *une fonction entière d'ordre* $\rho$ *et du type* $\sigma$. *Si les points d'une suite* $\{\zeta_n\}$ *vérifiant les conditions* (7) *et* (8) *sont situés dans un angle égal à* $2\alpha$, $0\leqslant 2\alpha<\pi$, *et dont le sommet est à l'origine, et si* $\sigma \leqslant \pi\nu\cos\rho\alpha$, *alors le système des fonctions* $\{F(n^{\frac{1}{\rho}}z)\}$ *est complet dans le cercle unitaire.*

Les théorèmes III, IV et V présentent une généralisation et une précision des théorèmes I et II d'un article de A. Gelfond (²). Dans cet article les conditions (7) et (8) sont remplacées par des conditions concernant l'existence des limites $\lim_{n\to\infty}\frac{\ln n}{\ln|\zeta_n|}=\mu>0$ et $\lim_{n\to\infty}\frac{n}{|\zeta_n|^\mu}=\nu>0$, et d'ailleurs dans le cas $\rho=\mu$ on fait l'hypothèse

$$\sigma<\frac{\nu}{\mu}2^{1-\mu}\int_0^1\frac{dx}{1-x^{1/\mu}}.*$$

Le théorème V a été énoncé et démontré dans l'article cité seulement pour $\rho=1$ et $\zeta_n=n$. Remarquons que la méthode de A. Gelfond est différente: elle est fondée sur la formule interpolatoire de Newton (pour son théorème I) et sur la transformation d'Hadamard (pour son théorème II). Son exposé, au point de vue du présent article, peut être considéré comme une application du critère de notre théorème I.

6. Le critère général présenté par le théorème II a pour conséquence encore plus immédiate que les théorèmes III, IV et V la proposition suivante:

Théorème 6. *Soit* $F(z)=\sum_0^\infty A_n z^n (A_n \neq 0,\ n=0, 1, 2, \ldots)$ *une fonction analytique dans le cercle unitaire et* $\{\zeta_n\}$, $|\zeta_n|<1$, *une suite de points, parmi lesquels il y a une infinité de points différents, ayant au moins un point limite à l'intérieur du cercle unitaire. Alors le système* $\{F(z\zeta_n)\}$ *est complet dans le cercle unitaire.*

Ce théorème se trouve aussi dans l'article cité de A. Gelfond (son théorème III) pour le cas où $\lim_{n\to\infty}\zeta_n=0$.

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* Cette dernière condition est nécessairement plus restrictive que la nôtre $\sigma<\frac{\nu}{e\mu}$ si $\mu>1+\frac{1}{\ln 2}$; cependant pour $\mu<\frac{1}{\ln 2}$ elle est moins restrictive que la nôtre.

7. Parmi les nombreux théorèmes particuliers que l'on peut déduire du théorème général II indiquons encore un:

Théorème 7. *Si* $F(z)=\sum_0^\infty A_n z^n (A_n \neq 0,\ n=0,\ 1,\ 2,\ \ldots)$ *est une fonction analytique dans le cercle unitaire, alors le système des fonctions* $\left\{\frac{F_n(z)}{z^n}\right\}$ *où les fonctions* $F_n(z)$ *sont déterminées successivement par les relations* $F_{n+1}(z)=\int_0^z F_n(z)\,dz$ $(F_0(z)=F(z))$ *est complet dans le cercle unitaire.*

Pour le démontrer on considère comme fonction $\Psi(z,\ \zeta)$ du théorème II la fonction

$$\Psi(z;\ \zeta)=\sum_0^\infty \frac{\Gamma(n+1)}{\Gamma(n+1-\zeta)} A_n z^n$$

En posant ensuite $\zeta^{(n)}=n$ $(n=0;\ 1,\ 2,\ \ldots)$, on obtient le système $\Psi(z, \zeta^{(n)})=z^n F^{(n)}(z)$ pour lequel un élève de A. Gelfond, à savoir I. Ibraguimoff [3], a démontré que c'est un système complet. En posant ensuite $\zeta_n=-n (n=0,\ 1,\ 2,\ \ldots)$ on démontre sans peine que les autres conditions du théorème II sont encore vérifiées, d'où il résulte que le système

$$\Psi(z,\ \zeta_n)=\frac{F_n(z)}{z^n}$$

est complet.

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*ASTRONOMY*

# STRUCTURE OF SOLAR CORONA OF SEPTEMBER 21, 1941

## (From Observations With Standard Coronographs)

By E. J. BUGOSLAVSKAYA

*(Communicated by S. I. Wawilow, Member of the Academy, 6.XII.1943)*

One of the tasks in the observations of the total solar eclipse on September 21, 1941, was to take photographs of the corona from different points of the totality zone with the aid of several standard coronographs, all of the same type ($F=5$ m, $D=100$ mm). By comparing photographs taken at different time it is possible to form a judgment on the changes that take place in the corona, and to determine the velocity of motion of coronal formations. If one ignores the isolated attempts to estimate the changes and motions of the corona from the observations of 1918 and 1926, work along this line in this country may be said to have started with the observations of the total eclipse of 1936. Then the zone of totality crossed all but the whole extent of the Union—from the North Caucasus to the Far East. The results obtained at that time have been reported in several papers ([1], [2]).

During the observation of the total eclipse of 1941 the standard coronographs that gave successful records, were placed at different points: Kzyl-Orda in the West (a party sent by the Tashkent observatory), Nikolaevka, the intermediate point (expedition of the Astronomical Institute of the Academy of Sciences of the USSR), and Jalanash, the point farthest to the East (expedition of the Sternberg Astronomical Institute, Moscow State University). Nikolaevka was chosen on account of its position near the northern boundary of the totality zone, where the observation of the polar chromosphere was planned. 22 photographs of the totality were obtained; 7 of them at Kzyl-Orda, 4 at Nikolaevka, and 11 at Jalanash.

The studies carried out by the author at Jalanash comprised: 1) careful investigation of coronal forms; 2) inquiry into their relation to the formations on the solar surface (the synoptic map of the Sun necessary for this work had been compiled from the observations of the Tashkent observatory); 3) study of the variation and measurement of the motions of coronal details on the basis of comparisons between photographs of the corona taken at different times.

These studies have lent support to the conclusions of S. Vsekhsviatsky and the author which they advanced in an earlier paper concerning the types of coronal forms and their correspondence to the formations observed on the Sun's surface. New information has also been secured on coronal forms and their variation in accordance with the above-mentioned formations.

The general appearance of the corona of September 21, 1941 approaches to the minimum type. Oblateness of isophotes is 0.85. The helmet-like streamers over the prominences are inclined towards the equator forming with the normal to the Sun's surface an average angle of 19° (from 5° to 32°). As has been shown by the author earlier, this angle varies with the phase of solar activity, and when the latter is at a minimum may attain 35°.

The details of the corona are typical forms determined by the formations of the Sun's surface. Forms of the same type correspond to a single type of formation on the solar surface. The former appear with the latter and are destroyed after these have vanished.

Prominence Systems. It has long been a matter of common knowledge that a system of arches and powerful streamers are observed over prominences in the corona. These arches are shells enveloping the prominences. Our observations confirmed this fact.

The line of symmetry of a regular system of arches in all but some particular cases corresponds to the point of eruption of the prominence (runs through it), rather than to the centre of the ejected matter.

The arches of the neighbouring systems easily penetrate each other without distortion.

The outer envelope comprising a system of arches has the shape of a helmet-like streamer. These shells terminate in long rays or a fan of diverging streamlets. The same dark flocculi give but one type of prominence and helmet.

Just what is the factor that influences the number of arches over a prominence, is it the intensity of eruption or the age of the prominence, cannot be said definitely at this juncture. Further investigation of this question is necessary. It is probable, however, that at first the inner arch is formed alone. In three young prominences the inner arch stands out most distinctly, whereas the outer ones are very faint. Over a prominence that lived for a second rotation five arches can easily be counted.

Over a decaying prominence the inner arch turned out to be faint. In the region of a vanished prominence which had last been seen on September 9, no system of arches can be detected, but there is something that appears to be a weak helmet.

The arches over prominences show a tendency to rise slightly, at a rate of 1—2 km/sec. This accords well with our former conclusions and with the measurements made by G. Horn d'Arturo during the eclipse of 1926.

The boundaries of the helmets showed no considerable displacement. In some cases velocities up to 4 km/sec. were determined. But these, to a great extent at least, may be accounted for by the rotation of the corona.

The prominences can be studied for their velocities of motion outside eclipses as well. During an eclipse one may trace the movement of small flocculi, detached from the main body of the prominence. Often these flocculi have close velocities in value and direction. Velocities of the order of 15 km/sec. are the most frequent. Clouds that have flown out of a prominence may fall back on the Sun again. The matter of which the prominences are made is dissociated into coronal matter. To put an example, a high density of coronal matter was observed where in the last rotation a prominence had been seen composed of a big mass of matter torn from the chromosphere; coronal clouds have often the same velocities with those arisen from a prominence.

During the eclipse of 1941 arches of a particular kind were observed. These are flat formations, linked up with the dark flocculi. They seem to connect one dark flocculus to another. In appearance they are different from the dome-like arches observed over the prominences. The recorded velocities of motion for the matter in these arches are of the order of 10 km/sec., as measured along the arch. In one case a displacement of the arch itself was noticed.

Region of Spots. It has already been established from the data for the eclipse of 1936 that straight radial rays emerge from the regions of faculae. The regions of the corona lying over the spots are characterized by a particularly strong excitation.

On September 21, 1941 there were two groups of spots and three regions of vanished groups near the limb of the Sun. From the spots ejected matter was flying off at a rate of 10 to 100 km/sec., apparently, along the force lines of the magnetic field of the spot.

These ejections were enveloped by coronal shells. In one group an expansion of the envelopes at a rate of 10 km/sec. was recorded.

Over a large group of spots ($s$ =2400 millionths of solar disc area) the ejections themselves were observed only on the 23 of September. The photographs show columns of coronal matter, a complicated system of envelopes and arches and, lastly, two external envelopes attaining in height 1.6 Sun's radii and comprising the whole formation. The external envelopes were shifting northward at a rate of 10—35 km/sec. Measurements of the clouds gave no reliable evidence; the most frequently recorded velocity was 15 km/sec.

The rays issuing from the faculae are bent in the regions of the groups, apparently under the influence of the magnetic field of the spots, and, embracing the coronal shells over the spots, travel in a broad, slightly diverging stream (the aperture angle of the rays is less than the angle within which spreads the facula; it was found to be 20° when the facula covered an angle of 30°).

The shells over the spots move more rapidly than those over the prominences.

The faint group of spots had disappeared on August 31. Its place on September 21 was near to the east border of the Sun's limb. No traces of it were visible in the corona. The other group had disappeared on September 5. Its development had been at maximum on August 8, when it had reached an area of 1374 millionths of the solar disc. Now disturbed rays indicated the place it had occupied in the corona. They showed displacement at a rate of 4 km/sec.

Polar Rays. The data for 1941 have furnished definite evidence that at the basis of polar rays chromosphere brushes are present which are projections with outflow in the apex, where the ray has a maximum intensity. These projections proved to lean from the normal to the Sun's surface in the same way as the polar rays; the rays and the chromosphere projections are influenced by the same forces of the Sun's field ([3]).

For the eclipse of 1936 the determination of the motion of polar rays had revealed velocities not exceeding 1 km/sec. Now, in 1941, two rays were found to be in relative displacement of the order of 5 km/sec. Suppose this is only an apparent displacement, and the site of maximum intensity of the ray has virtually shifted on account of an ejection of matter by the neighbouring chromosphere brushes; then the speed of matter along the ray should be no less than 100 km/sec.

From such studies of coronal forms one may decide upon which stream of particles corresponds to some particular formation observed on the solar surface. They also throw light on the problem of the influence the active regions of the Sun have on the Earth.

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*PHYSICS*

## ON APPARENT MAGNETIZATION

By V. K. ARKADIEV, Corresponding Member of the Academy, and L. A. YUROVSKY

A very important point in magnetic measurements and non-destructive tests is that the body under investigation should be thoroughly demagnetized. The ordinary way to bring it into this state is by placing the body in a gradually decreasing alternating field of a sufficient initial intensity.

However, an electromagnetic periodic field of industrial frequency is rapidly damped in a ferromagnetic metal and thus prevented from getting deep into it. So a complete demagnetization is not always obtained.

Let us magnetize a ferromagnetic cylinder in a homogeneous magnetic field (before we do so, the cylinder has to be completely demagnetized, say, by heating above the Curie point). Place it then in a sinusoidal field with a maximum amplitude not smaller than the potential of the field that has created the magnetic state in the cylinder, and let this periodic field be smoothly and slowly reduced to zero.

Such a cylinder may behave in relation to a magnetometer, ballistic coil of a galvanometer circuit, *etc.*, as if it were perfectly demagnetized, though in reality, unless a very thin cylinder, it still retains considerable magnetization inside.

Because of the skin effect a variable magnetic field will not, indeed, penetrate inside the cylinder beyond a certain depth $z_1$. The simplest way of computing the skin effect in a ferromagnetic for a strong field is to suppose the induction to have the steep front.

Then, taking into consideration that the accuracy of such calculation is generally not high, we can assume that a not deep penetration of the field in the cylinder proceeds according to the same law as into a half-space or plate. In the case of a plate we have([1],[2])

$$z_1 = \sqrt{\frac{I}{2\pi\gamma 2B_\text{J}}} \qquad (1)$$

where $I = \int_0^t (H - H_c)\,dt$ is the impulse of the magnetic field.

Here $\gamma$ is the electric conductivity of the cylinder; $2B_\text{J}$, change of magnetic induction from $-B_\text{J}$ to $+B_\text{J}$; $H_c$, coercive force; $H$, magnetic field acting for an interval of time $t$.

For a sinusoidal variation of $H$ in a half-period

$$I = H \int_0^{\frac{T}{2}} \sin \omega t\, dt = \frac{2H}{\omega}.$$

In the case of carbon steel $H_c$ is a magnitude of the order 9 — 20 Oe.

Since $H$ ranges from 100 to 150 Oe, we have $I = 1$ for $\omega = 314$. Substituting in (1) $\gamma = 5 \times 10^{-5}$, $B_\text{J} = 20000$, we find $z_1 = 0.3$ cm.

This will mean that a cylinder one or several centimeters in diameter is demagnetized only to a depth of several millimeters, while its inner layers remain in the state of magnetization. Experiments that we describe hereafter have shown that because the layers lying on the rather vague boundary $z_1$ and somewhat deeper down are at once under the influence of a constant demagnetizing field of the cylinder's poles and of a variable demagnetizing field vanishing in time (see below), they are magnetized, as a matter of fact, in the opposite direction to the original one, and, in case the section of the cylinder is sufficient, form a magnetic conductor through which the remaining magnetic flux of the magnet travels back from the axis.

The observations were carried on as follows.

Short iron and steel cylinders, first magnetized in a uniform constant field, then demagnetized in a periodic field of the chosen frequency, were etched in a solution of aqua regia (3 parts of $HCl + 1$ part of $HNO_3$).

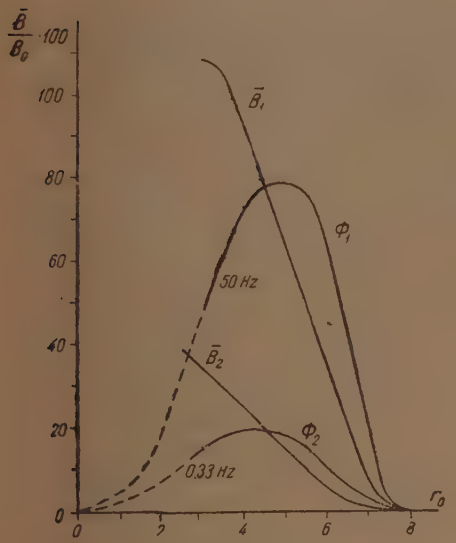


Fig. 1. Induction curves in the course of dissolution of apparently demagnetized cylinders. $\Lambda = 7.5$, $l = 12$ cm, $2r_0 = 1.6$ cm

| Demagnetizing field | | Coercive force $H_c$ | Magnetizing field $H$ | Initial induction $B_0$ |
|---|---|---|---|---|
| $f$ | $H_{max}$ | | | |
| 50 Hz | 170 Oe | 20 Oe | 120 Oe | 427 Gs |
| 0.33 Hz | 150 Oe | 9.5 Oe | 120 Oe | 283 Gs |

Measurements of the residual induction were made from time to time as the cylinder decreased in diameter and each time it was pulled out for this purpose from the ballistic coil connected with a galvanometer. It was found out that after the dissolution of the superficial layers the magnetic flux $\Phi$ of the demagnetized cylinders increased gradually as the cylinder became thinner (Fig. 1, curves for $\Phi_1$ and $\Phi_2$). The induction $\bar{B} = \frac{\Phi}{\pi r^2}$, average for the section, measured after the cylinder was demagnetized and its radius decreased, as a result of etching, from $r_0$ to $r_a$, is represented in Fig. 1 by curves $\frac{\bar{B}}{B_0} \cdot 100$ per cent, where $B_0$ is the induction displayed by the cylinder before its demagnetizing in the periodic field.

In Fig. 1 the curve $\bar{B}_1$ has risen above 100 per cent. This is owing to the fact that with the rod decreasing in diameter, its demagnetizing factor decreases also and so does the field demagnetizing the body. Accordingly, an increase of magnetization with respect to the particular cycle takes place (3).

Let us now determine the character of the distribution of magnetization over the section of the cylinder.

In the experiment we measured the apparent induction $\bar{B}$ which the cylinder displayed when pulled out of the ballistic coil. This induction $\bar{B}$ for a given cy-

linder of radius $r_a$ is defined by the equation

$$\overline{B}\pi r_a^2 = \int_0^{r_a} 2\pi r B(r)\, dr.$$

Since $\overline{B}$ is a function of the radius of the cylinder, we have, after differentiation with respect to $r_a$

$$B(r_a) = B + \frac{d\overline{B}}{dr_a}\frac{r_a}{2}.$$

Here $B\ (r_a)$ is induction on the surface of a cylinder of radius $r_a$. Supposing the induction of a given inner layer to suffer no change when this layer becomes

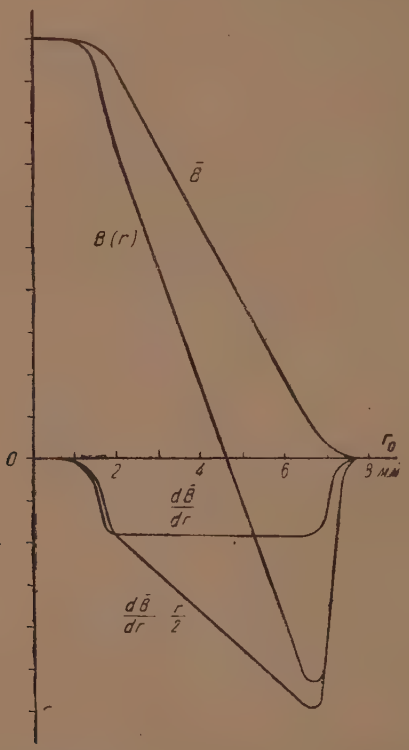


Fig. 2. $B(r)$ curve, distribution of magnetic induction along the radius of cylinder, on the assumption that $B(r) = B(r_a)$

the surface layer through etching, we can take the latter expression of $B\ (r_a)$ for the real distribution of the induction $B(r)$ over the cross-section of the cylinder (Fig. 2).

Thus calculated, the curve $B\ (r)$ shows that the thick cylinder while in a smoothly decreasing periodic field of frequency $f = 50$ Hz is demagnetized but externally, and the rest of its layers continue in the state of magnetization being partly magnetized in one, partly in the other direction (Fig. 3). Such a cylinder when viewed from its butt end presents inside the following picture. The core $\alpha$ is not demagnetized at all and has an induction equal to or even higher than the induction of the entire cylinder before demagnetization ($B_0$).

The layer next to it, β, is only partly demagnetized and the extent of its demagnetization is in inverse relation to its distance from the surface. The sign of magnetization is here the same as in the core.

In the layer γ the induction is opposite in sign to that of the two preceding portions of the cylinder. The inversely directed magnetization of this layer compensates the field of the layers α and β. The field of the cylinder does not extend its action as far as to the layer δ. This layer, being under a strong influence of the external demagnetizing alternating field, is entirely deprived of magnetization.

Fig. 3. Distribution of residual flux in an apparently demagnetized cylinder

It is obvious that in very thick cylinders when the flux of the layer γ cannot offset the flux of the core, the layer δ will be absent. The thickness of this layer depends largely on the period of the demagnetizing field and its maximum amplitude (1).

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*PHYSICS*

# PROTON RECORDING SENSITIVITY OF EMULSIONS TREATED FOR REMOVAL OF BACKGROUND

By N. A. PERFILOV

*(Communicated by V. G. Chlopin, Member of the Academy, 10.XI.1943)*

By treating the sensitive layer of a photographic plate with oxidizers it is possible under certain conditions to remove the background due to α-particles and protons without affecting appreciably the sensitivity of the layer to further registration of α-particles (1). The experiments described in this paper have been carried out in order to establish whether the sensitivity of photographic emulsions to protons does or does not diminish as a result of treatment with oxidizers for the removal of the background.

Three thick-layer photographic plates, all cut-out of a single plate coated with a proton sensitive emulsion, were subjected to preliminary treatment under conditions referred to in Table 1. From the same plate the control was cut out, which was not treated. The control as well as the test pieces were irradiated with fast neutrons from the source RaTh+Be. The protons were produced by the collision of neutrons with hydrogen atoms entering into the composition of the gelatine. From γ-radiation the plates were partly screened by a layer of lead, whose thickness and time of exposure had been so chosen by trial as not to allow the background of γ-rays to interfere with microscopic examination.

Table 1

| Oxidizer | Concentration of water solutions in g/cm³ | Bathing interval | Washing | Drying |
|---|---|---|---|---|
| $H_2CrO_4$ . . . . | 1 : 5000 | — | About 40 min. in repeatedly changed distilled water | Removal of excessive water by alcohol and ultimate drying in a current of dry air at 30°C |
| $K_3Fe(CN)_6$ . $KMnO_4$ . . | 1 : 10000 | 15 min. | | |

When the plates irradiated with neutrons had been developed, the number of proton tracks they contained was counted and the projection of every track into the plane of the plate was measured by means of ocular scale. In the following the length of a projection will be taken for the length of the respective track, since for the purposes of comparison not the true values of length but rather the uniformity of their determination is of importance. In counting up the tracks on every plate at definite and equal intervals 55 fields of vision were examined. The area of a single field was 0.09 mm². The results of the experiment sare given in Table 2.

Table 2

| Plates | Number of proton tracks | | Total length of tracks in μ | Average length of one track in μ | Number of protons with path length in emulsion ⩾ 100 μ |
|---|---|---|---|---|---|
| | on a plate | on 1 mm² | | | |
| Control | 226 | 45 | 8311 | 36.8 | 15 |
| Treated with $H_2CrO_4$ | 232 | 46 | 8347 | 36.0 | 15 |
| Treated with $K_3Fe(CN)_6$ | 218 | 44 | 7695 | 35.3 | 16 |
| Treated with $KMnO_4$ | 220 | 44 | 8352 | 37.9 | 17 |

What may be inferred from these data is this. A photographic emulsion that enjoys the property of recording protons retains it undiminished when treated for removal of background under conditions referred to in Table 1. The sensitivity of the emulsion rests invariant not merely in respect to the number of recorded protons, but also to their path length. This follows from the fact that the mean path is constant for all plates and the number of long path protons ($R \geqslant 100$) with energy above 3 MeV is not less in the treated plates than in the control.

To get a still more convincing proof I have measured the average distance between the grains for 20 tracks of recoil protons in the control plate and in the

plate treated with chromic acid. One half of this number of tracks had a path in the emulsion from 70 to 100 μ long, the other half ranged in path length from 100 to 200 μ. If referred to the air instead of emulsion, these figures give a range of approximately 10 to 29 cm, or, in terms of energy, 2.4 to 4.6 MeV. The averaged distance between the grains is 3.40 μ for the control plate; 3.37 μ for the treated plate, which is practically the same. This also confirms the conclusion made above.

In the figure photomicrographs of two proton tracks are shown, found in the plates treated with chromic acid ($R=185$ μ) and with potassium ferricyanide ($R=114$ μ). The proton tracks are bounded with arrow heads. The dotted background is due to hard γ-rays of radiothorium.

The author is indebted to A. P. Zhdanov fort he interest he has taken in this work.

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*CHEMISTRY*

# ALUMOTHERMAL PRODUCTION OF LOW-CARBON INTERMEDIARY ALLOYS AND FERROCHROME

By I. I. KORNILOV and V. S. MIKHEEV

*(Communicated by I. I. Černjaev, Member of the Academy, 14.X.1943)*

The preparation of heat-resistant iron-chrome-aluminium alloys Nos. 1 and 2 involves the use of low-carbon intermediary alloys (1). Until recently a chrome-aluminium alloy obtained alumothermally from chromium oxide served for this purpose (2).

In the course of further research the chromium-bearing ore of Aktiubinsk was suggested as a source in manufacturing alloys free of carbon. But this ore is too high in silica to produce from it an alloy conformable to the standard in respect to content of silicon.

Then there were made successful attempts to reduce the content of silica in this ore and to increase its ratio of chromium oxide by dressing (3). In this way was proved the practical possibility of obtaining a concentrate containing 61—63 per cent of chromium oxide and not above 0.5 per cent of silica from an ore with 50—55 per cent of chromium oxide and 5—10 per cent of silica.

It appeared, however, from the data on the heat balance of the reaction in which chromium and iron oxides are reduced from the just mentioned concentrate by means of aluminium that the heat of reaction was not sufficient for the process of alloy formation to be carried out. Some additional quantities of oxygen had to be introduced into the system. This was done by using different accelerators, such as potassium or sodium nitrate, potassium chlorate, ferrous-ferric oxides ($FeOFe_2O_3$) *etc.* By comparing the heat balance data obtained with different accelerators the optimal compositions of the charge materials for the production of the alloy of required composition were established.

In manufacturing the intermediary ferro-chrome-aluminium alloy the raw concentrate of the chromite is subjected to preliminary drying and roasting. The latter operation is more expedient than the simple removal of mixture. Upon roasting within a range of 800—900°C a partial decomposition of the chromite takes place, its ferrous oxide is oxidized to ferric oxide according to the equation $2\,FeO + 1.5\,O_2 = Fe_2O_3$, and the carbon-containing substances of the concentrate are burned out.

The roasted concentrate involved in the smelting had the following composition (average sample in per cent by weight):

| $CrO_3$ | $Fe_2O_3$* | $SiO_2$ | $MgO$ | $Al_2O_3$ |
|---|---|---|---|---|
| 63.89 | 15.01 | 0.45 | 12.77 | 9.18 |

The aluminium powder contained 0.55 per cent of silicon and up to 0.5 per cent of copper.

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* No analysis data for the FeO being available, all iron of the concentrate was recalculated for iron oxide.

The accelerators were mostly commercial products and contained admixture within the limits of the existing standards. Lime (freshly calcined) was used in smelting as a flux in order to lower the high melting temperature of the slags rich in alumina. The preparation of the charge, mixing and smelting were done in the same way, as in smelting the alloy of chromium with aluminium (2). In Table 1 we give data on the composition of the charge and the resulting alloy.

Table

Ternary Alloy of Ferro-chrome-aluminium

| Smeltings | Accelerators and slag, % in the charge | Analysis data | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | C | Cr | Fe | Al | Si | Mn | S |
| | Laboratory tests; charge, 50 kg | | | | | | | |
| 1 | 20% $NaNO_3$ without slag | 0.04 | 66.74 | 15.68 | 16.62 | 0.65 | 0.27 | 0.019 |
| 2 | 10% $NaNO_3$ » » | 0.04 | 68.84 | 17.00 | 13.16 | 0.70 | 0.16 | 0.012 |
| 3 | 15% $NaNO_3$ + 25% CaO | 0.08 | 60.94 | 14.02 | 24.39 | 0.56 | — | 0.012 |
| 4 | 15% $KClO_3$ + 10% $K_2Cr_2O_7$ + 26% CaO | 0.05 | 59.94 | 14.84 | 25.04 | 0.75 | — | 0.015 |
| 5 | 20% $KClO_3$ + 10% $K_2Cr_2O_7$ + 26% CaO | 0.03 | 55.24 | 13.57 | 29.70 | 1.11 | 0.28 | — |
| 6 | 30% $KClO_3$ + 26% CaO | 0.03 | 52.80 | 14.00 | 31.70 | 1.02 | 0.26 | — |
| 7 | 20% $KClO_3$ + 20% $Fe_3O_4$ (iron magnetite) | 0.05 | 33.68 | 35.24 | 31.70 | 1.13 | 0.33 | — |
| | Factory tests; charge, 1000 kg | | | | | | | |
| 0 | 12% $NaNO_3$ + 5% $K_2Cr_2O_7$ | 0.02 | 66.00 | 17.61 | 16.08 | 0.23 | — | — |
| 1B | 10% $KNO_3$ + 5% $KClO_3$ without slag | 0.05 | 66.20 | 18.60 | 14.50 | 0.80 | — | — |
| 2B | 12.5% $KNO_3$ + 7.5% $KClO_3$ + 26% CaO | 0.06 | 65.06 | 19.00 | 14.00 | 1.38 | — | — |
| 3B | 10% $KNO_3$ + 8% $K_2Cr_2O_7$ + 5% $KClO_3$ | 0.025 | 67.67 | 15.99 | 15.40 | 0.92 | — | — |
| 4B | 10% $KNO_3$ + 8% $K_2Cr_2O_7$ + 5% $KClO_3$ | 0.015 | 65.82 | 17.45 | 15.49 | 0.96 | — | — |
| 5B | 15% $KNO_3$ + 15% CaO | 0.010 | 65.67 | 17.61 | 15.45 | 0.98 | — | — |
| 6B | 15% $NaNO_3$ + 15% CaO | 0.022 | 66.21 | 16.75 | 16.12 | 1.10 | — | 0.012 |
| 7B | 13% $NaNO_3$ + 15% CaO | 0.025 | 65.68 | 16.80 | 17.10 | 0.93 | — | 0.013 |

As is seen from these data, the alloy thus obtained fully conforms to the standard and is fit to be used as intermediary alloy in manufacturing the heat-resistant alloys Nos. 1 and 2. Its content of carbon is not above 0.06 per cent. The content of silicon varies from 0.6 to 1.35 per cent. It contains 55 to 68 per cent of chromium and 15—25 per cent of aluminium. The content of aluminium varies according to the different need for it in smelting the alloy No. 1, as compared to No. 2.

As there is a surplus of aluminium in the reacting mixture, a most complete reduction of the oxides takes place. The content of chromium oxide in the slag is only 1—2.5 per cent; of ferrous oxite, 0.20—1.50 per cent; and of silica 0.10—0.60 per cent. The content of calcium oxide varies according to the proportion in which this compound has been introduced in the charge to lower the slag's melting temperature.

From the low silica chromite concentrate a low-carbon ferrochrome may as well be obtained by this method. The reduction of oxides from the concentrate was calculated in the same way whether ferrochrome or the intermediary alloy was to be the ultimate product. The only difference is that in calculating the charge composition for ferrochrome the reduction ratios of chromic oxide and ferrous oxide were lowered down to 85 and 95 per cent, respectively, and as much aluminium was included as is necessary for their reduction.

Test smelting with the ore of different accelerators have proved the possibility of obtaining a carbon-free ferrochrome of high quality, such as cannot be produced by any of the existing methods. The analysis data for this ferrochrome and the composition of the charge are given in Table 2.

Table 2

Low-Carbon Ferrochrome

| Smeltings | Accelerators and slag, % in the charge | Analysis data | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | C | Cr | Fe | Al | Si | Mn | S |
| | Laboratory tests; charge, 50 kg | | | | | | | |
| 1X | 10% $NaNO_3$ without slag . . . . | 0.04 | 72.02 | 17.92 | 8.02 | 0.94 | 0.26 | 0.011 |
| 2X | 10% $NaNO_3$ + 2% $K_2Cr_2O_7$ + 26% CaO . . . . . | 0.06 | 75.90 | 15.68 | 7.28 | 1.42 | — | 0.012 |
| 3X | 20% $KNO_3$ + 5% $K_2Cr_2O_7$ . . . . | 0.07 | 75.46 | 20.36 | 3.15 | 0.94 | — | — |
| 4X | 15% $KNO_3$ + 5% $K_2Cr_2O_7$ . . . . | 0.04 | 77.20 | 21.00 | 0.65 | 0.94 | 0.183 | — |
| 5X | 12% $KNO_3$ + 6% $K_2Cr_2O_7$ . . . . | 0.03 | 77.02 | 21.70 | 0.48 | 0.60 | 0.165 | — |
| 6X | 15% $KNO_3$ + 5% $K_2Cr_2O_7$ . . . . | 0.02 | 73.87 | 25.62 | 0.30 | 0.23 | — | — |
| | Factory tests; charge, 1000 kg | | | | | | | |
| 6X | 12.5% $KNO_3$ + 5% $K_2Cr_2O_7$ without slag . . . . . | 0.04 | 76.91 | 19.85 | 2.06 | 0.96 | — | 0.012 |
| 2BX | 12.5% $KNO_3$ without slag . . . | 0.03 | 77.78 | 21.00 | 0.23 | 0.63 | — | — |
| 3BX | 12.5% $KNO_3$ + 6% $K_2Cr_2O_7$ without slag . . . . . | 0.03 | 78.64 | 20.65 | 0.14 | 0.47 | — | 0.015 |
| 4BX | 10% $NaNO_3$ + 15% CaO . . . . . | 0.02 | 78.09 | 20.98 | 0.36 | 0.51 | — | — |
| 5BX | 14% $NaNO_3$ + 15% CaO . . . . . | 0.025 | 76.25 | 21.98 | 0.61 | 0.62 | — | — |

It is seen from Table 2 that the content of chromium in the ferrochrome is 75 to 78 per cent (but not below 70 per cent); that of carbon does not exceed 0.05 per cent and ranges actually within 0.02—0.04 per cent in the factory smeltings; the content of aluminium varies in most cases from 0.14 to 0.60 per cent, and there is up to 1 per cent of silicon.

In the classification in which the available brands of low-carbon ferrochrome are arranged in an increasing zero series (0, 00, 000 and 0000), our ferrochrome is to be placed as a new brand with not above 0.04 per cent of carbon and from 75 to 78 per cent of chromium. It is destined for use in manufacturing stainless and heat-resistant steels of the highest quality with a sharply reduced content of carbon. In those steels the content of carbon is under 0.05—0.06 per cent, which makes them highly resistant to corrosion and heat.

Conclusions. 1) An alumothermal method for the production of ferrochrome and low-carbon ferro-chrome-aluminium intermediary alloys has been developed on the basis of a low silica concentrate from Aktiubinsk chromite.

2) The proper compositions of the charge ingredients and of the accelerator destined to promote the reduction of chromium and iron oxides from the chromite concentrate have been determined.

3) The ferro-chrome-aluminium alloys produced by this method are intended to be used as intermediary alloys in manufacturing the heat-resistant iron-chrome-aluminium alloys Nos. 1 and 2, while the low-carbon ferrochrome is destined for the preparation of high-grade stainless and other heat-resistant steels.

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*GEOCHEMISTRY*

# ON THE REGULARITIES UNDERLYING VARIATION OF THE COMPONENTS OF THE ASH OF COALS FROM THE DONETZ COAL BASIN

By G. I. EGOROV

*(Communicated by P. I. Stepanov, Member of the Academy, 25.VIII.1943)*

1. This paper is concerned with the zonal variation in the composition of the ash of coal in the area of the Donetz basin. It is insumming up the vast material obtained by the All-Union Coal Institute of the People's Commissariat for Coal that was compiled a geological and chemical map of the Donetz basin. The work has been published in the 4 volumes of a unique monograph on the coals of the Donetz basin.

In finding out the variation in the composition of the ash in the coals throughout the area of the Donetz basin (old Donbass), the author has intentionally excluded from the treatment of the analyses of the ash, the computation of the composition of the ash according to individual series. His purpose was to unify the indices of the composition of the ash for all the series as a whole, beginning with series $C_{2\gamma}^{1}$ bed $f$—Nasledyshevsky—to series $C_{3}^{1}$, bed $n_1$—Valyuga (Central region). Such a generalization should permit to disclose the relations leading to more valuable geological conclusions than would give the determination of regular variation in the composition of ash according to individual series. Within the area of the Donetz basin analogous coal beds are worked not in all the regions. The author found it expedient therefore to study the laws governing the variation in the composition of the ash in individual series as an independent problem which will we solved at the next stage of his work.

| Regions | Composition of ash | | | | |
|---|---|---|---|---|---|
| | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO |
| Lisichansk | 29.54 | 14.75 | 38.21 | 12.86 | 0.85 |
| Pervomaisk | 28.09 | 15.87 | 39.54 | 8.74 | 1.00 |
| Krasnoarmeysk | 35.80 | 19.90 | 29.00 | 7.25 | 1.68 |
| Central | 32.08 | 18.80 | 40.21 | 5.07 | 0.87 |
| Stalino | 36.05 | 22.51 | 28.96 | 6.09 | 0.94 |
| Mospin | 26.74 | 22.17 | 26.03 | 13.24 | 0.96 |
| Chistiakov | 40.54 | 21.59 | 25.58 | 5.09 | 2.01 |
| Khrustalsk | 49.70 | 22.25 | 17.54 | 2.09 | 1.31 |
| Krasnodon | 22.20 | 14.32 | 42.75 | 8.04 | 1.38 |
| Shakhty | 46.99 | 22.80 | 22.22 | 1.84 | 0.87 |
| Buguraev | 20.15 | 12.30 | 49.55 | 8.71 | 1.23 |

In computing the components of the ash, the author has separated out eleven regions, of which some entirely correspond to the workable regions of the Donetz

basin (Lisichansk, Pervomaisk, Krasnoarmeysk, Shakhty, Buguraev), while others (such as Krasnodon and Mospin) are united regions comprising a number of productive regions of the Donetz basin.

Within the boundaries of the above 11 regions, the weighed averaged composition of the ash was computed according to the working beds of the coals, which the author believed to present the possibility of any considerable distortion of the data of computation.

Fig. 1

2. As a result of the treatment, the table given above was prepared, in which the data of the averaged weighed composition of the ash of coals are given according to the corresponding regions.

3. On the basis of the averaged weighed composition of the ash, the isolines of equal content of a given component of the ash were plotted, which enabled to show the trend in the variation of the components of ash, their magnitude and relation to the geological structure of the basin.

4. From the accompanying graphs (Figs. 1—5) it will be seen that the components of the ash—$SiO_2$, $Al_2O_3$, $Fe_2O_3$, CaO and MgO—have peculiar isolines which in some cases coincide in some features, being different on the whole.

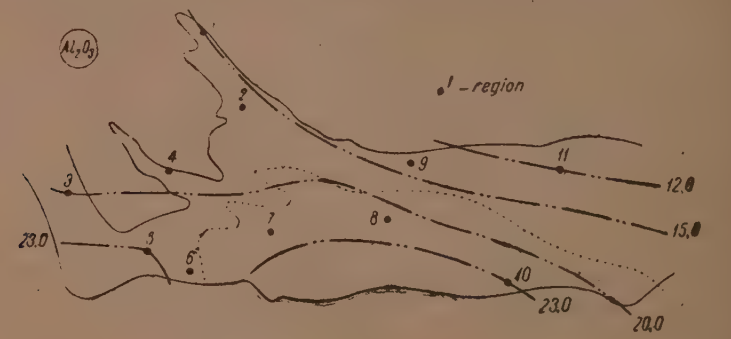


Fig. 2

Let us discuss the trend of variation in the composition of individual components in the area of the basin.

$SiO_2$. In the quantitative composition of the ash its content varies within the range of 20.15 to 49.70 per cent. The zonal distribution within the area of the basin is characterized by a decrease in the content of the ash from South to North within the range of the above qualitative indices (Fig. 1). In the eastern part of the basin the $SiO_2$ content of ash decreases from South to North. In the western part there are observed: (1) a coincidence of the isolines with the axis of the main anticline; (2) a symmetrical closure of the isolines to the North-East and South-West from the axis, this symmetrical closure coinciding with the boundary between coking coals and anthracites (see dotted lines in Fig. 1).

$Al_2O_3$. The content in the ash within the area of the basin ranges from 12.30 to 22.80 per cent. Similarly to $SiO_2$, the $Al_2O_3$ content in the area of the basin decreases from South to North. This variation is steady both for the eastern and the western part of the basin. The isolines of $Al_2O_3$ show an almost rectilinear direction (Fig. 2).

$Fe_2O_3$. The content in the ash within the area of the basin varies from 17.51 to 49.55 per cent. The zonal distribution of $Fe_2O_3$ is characterized by an increase

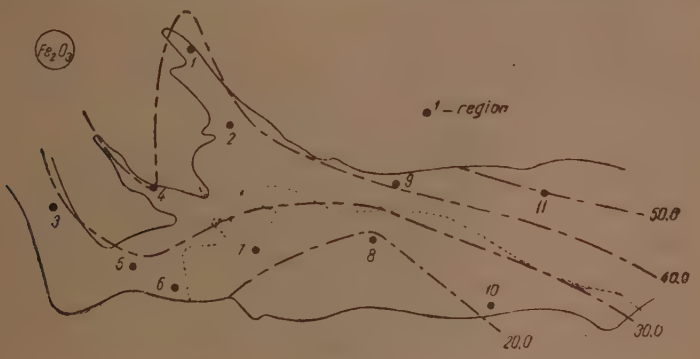


Fig. 3

of its content from South to North, *i. e.* in a direction reverse to the variation of the composition of $SiO_2$ and $Al_2O_2$. For this component of ash, as well as for $Al_2O_3$, a nearly rectilinear direction of the isolines is observed. An exception is the variation of the direction of isolines of 40 per cent in the western part of the basin (Fig. 3).

CaO. The content in the ash within the area of the basin varies from 1.81 to 13.24 per cent. The general trend is similar to that of $Fe_2O_3$, its content in the ash increasing from South to North; in the western part the configurations of the isolines of CaO nearly coincide with those for $SiO_2$ (Figs. 1 and 4).

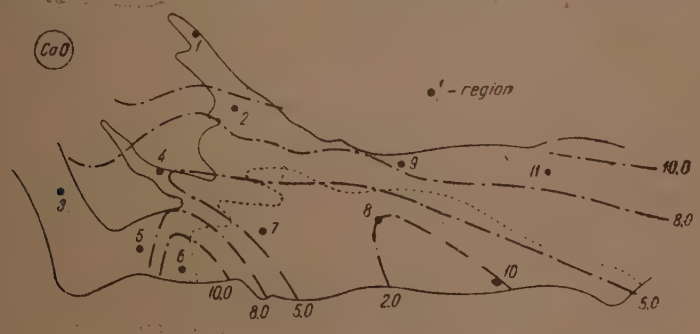


Fig. 4

MgO. The content in the ash within the area of the basin ranges within 0.85 to 2.01 per cent. The general regularity consists in a decrease of content from the centre of the basin to the South-East, North-East, North-West and West. In the extreme western part of the basin there is observed an increase in the MgO content up to 1.68 per cent (Fig. 5).

5. On the whole, there is a correlation between the increase or decrease of a definite component and the reduction of carbonification, as well as between the changes in the content of individual components of the ash and a decrease in the thickness of the coal-bearing Carboniferous deposits.

In considering the particular cases of the regular variation of the ash it is observed that: (1) with a decrease in the thickness of the coal-bearing deposits and a

change of the granulometric composition of sandstones to the North and North-West there is a decrease in the $SiO_2$ and $Al_2O_3$ content of the ash; (2) to an increase of CaO and $Fe_2O_3$ in this direction corresponds an increase in the thickness of limestones (on the platform the coal-bearing Carboniferous deposits have been entirely replaced by the limestone facies), and an increase in the concretional siderite inclusions in the Carboniferous coal-bearing deposits. This regularity seems to be accounted for by genetical causes of sedimentation. Chemical and petrographical investigation of the enclosing rocks, in which it will also be possible to discover regular change of the composition, may yield support to this view.

The practical aspect of the study of the composition of the ash shows that in the northern regions of the Donetz basin, owing to the presence of a large amount

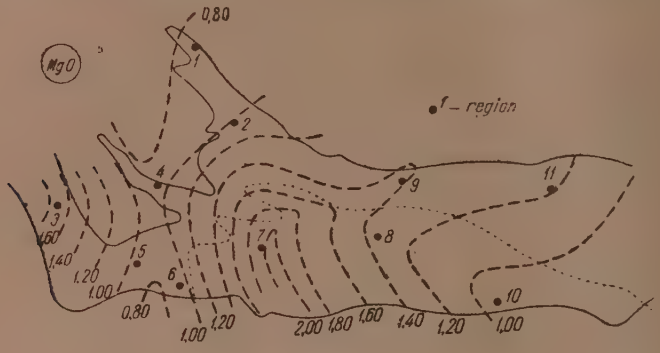


Fig. 5

of CaO and $Fe_2O_3$ in the ash, the ashes in the coals must be more readily fusible than the coals from the southern regions, *i. e.* along with a reduced carbonification a decrease in the temperature of fusion of the ash is likely to be observed.

6. The relation between the structural forms and the mode of behaviour of the isolines of the components is obscure. It should only be pointed out that the isolines of the components $SiO_2$, CaO and $Fe_2O_3$ seem to encircle the main anticline from the South and North and to form a number of complicated configurations, coinciding with the areas of complicated structures, developed in the western part of the basin.

The encircling of the main anticline by the isolines may account for the existence of an uplift at the period of sedimentation in the area of the main anticline, and in this juncture for the uniform distribution of the components of the ash near the outlines of the uplift.

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*GEOLOGY*

# A TENTATIVE QUANTITATIVE STUDY OF THE GROWTH AND TIME OF FORMATION OF THE SHUGUROV UPLIFT

By A. B. RONOV

*(Communicated by V. G. Chlopin, Member of the Academy, 1.XI.1943)*

The Shugurov uplift is located in the south-eastern part of Tataria, in the upper course of the Sheshma river. G. P. Zhusé, who carried out here a structural survey in 1939, found that the Shugurov uplift is a brachyanticline with a north-eastern strike of the long axis. Its length in this direction is about 20 km, and the width, about 8 km. The angles of dip are very gentle and do not exceed 2°, the eastern limb being steeper than the western one.

According to the data of drilling with Krelius drills carried out here, S. P. Egorov has prepared structural maps of the uplift after the basic horizon in the Schwagerina beds of the Upper Carboniferous and the roof of the Artinskian, Ufa and Lower Kazan deposits of the Permian.

The forms of the structural surface and the configuration of its components are more or less similar in the deposits of the Upper Carboniferous and the Artinskian stage. Beginning with the Ufa time the structural maps record a shifting of the arch portion in a north-eastern direction. The magnitude of the shifting by the close of the Lower Kazan age reached 5.5 km.

Along with this a gradual simplification and flattening of the higher horizons is noted.

The above facts suggested to the author the idea of seeking for objective quantitative criteria for evaluating the degree of crumpling of each horizon.

1. Determination of Value and Amount of Crumpling. The degree of crumpling of any stratum in the brachyanticline is determined by the volume of the space enclosed between a horizontal plane drawn through the lower strato-structure contour and the surface of the curved stratum. Naturally, when the attitude of the stratum is horizontal, the volume of its crumpling is zero. As the angles of dip are increased, and the structural form becomes more complicated, the volume of crumpling of the stratum increases. The greater the bending of the stratum, the greater is the volume of its crumpling.

The method for measuring crumpling volumes suggested below makes it possible to compare the intensity of the crumpling processes of different structural horizons in time. The procedure of determination of the volumes consists in comparatively simple measurements on the structural maps of the horizon studied.

On all the maps the same constant area is taken, confined with drill-holes located on the periphery of the brachyanticline. In this way structural constructions not based on facts are rejected in the subsequent measurements.

The strato-structure contour with the lowest altitude mark is taken as zero. The altitude marks of all the following strato-structure contours of the stratum ($h$) are recalculated with respect to the zero surface. The difference between the

strato-structure contour with the maximum mark, and that with the lowest (zero) mark gives the full height of crumpling of a stratum.

The determination of the total volume of crumpling is made by the approximate measurement method. On the structural map the area ($S$) is determined enclosed within the strato-structure contour with the maximum altitude mark, which is subsequently multiplied by the average height $\frac{(h_1+h_2)}{2}$. As a result, the volume of crumpling of the arch portion of the stratum is obtained

$$V_c^1 = S_1 \left(\frac{h_1+h_2}{2}\right) \text{km}^3. \quad (1)$$

Then the volume of crumpling ($V_c^2$) is determined for that portion of the stratum which is located between the maximum and the next, lower, strato-structure contour. Repeating these measurements one after another, from areas with maximum altitude marks to an area bounded by the zero strato-structure contour, a series of particular volumes is obtained, the sum of which gives the total volume of crumpling of the stratum

$$V_c = (V_c^1 + V_c^2 + \ldots + V_c^n)\,\text{km}^3 \quad (2)$$

where $n$ is the number of strato-structure contours.

From the total volume of crumpling ($V_c$) the average amount of crumpling is deduced; in other words, the average height of crumpling of the stratum

$$h_c = \frac{V_c}{S}\,\text{km}^3/\text{km}^2 \quad (3)$$

where $S$ is the area investigated, bounded with drill-holes following the periphery of the brachyanticline.

The magnitude of the average amount of crumpling ($h_c$) expresses in kilometers the intensity of crumpling of the stratum. After a series of $h_c$ for different horizons have been determined, it becomes possible to compare the intensity of the crumpling processes in time.

2. Volumes and Amounts of Crumpling of Different Horizons of the Shugurov Uplift. Using the structural maps prepared by S. P. Egorov, the author measured and computed the volumes and amount of crumpling of the base horizon of the Upper Carboniferous, the surface of Artinskian deposits, the roof of Ufa and Lower Kazan deposits. In carrying out the measurements, the author restricted himself to the constant contour drawn through holes drilled with Krelius drills, Nos. 27, 10/26, 9, 6, 19, 18, 16, 15, 11, 3. The results of measurements and calculations are summarized in the table below.

| Surface measured | Height of brachyanticline, m | Area, km² | Volume of crumpling, km³ | Average amount of crumpling, km | Average amount of subsidence of the Earth's crust, km | Rate of subsidence of the Earth's crust, km/10⁶ years |
|---|---|---|---|---|---|---|
| Mean horizon of the Upper Carboniferous ($C_3$) . . . . . | 70 | 122 | 5.65 | 0.046 | — | — |
| Surface of Artinskian stage ($P_1^{art}$) . . . . . | 70 | 122 | 5.81 | 0.048 | 0.106 | 0.011 |
| Roof of Ufa strata ($P_{1-2}^{uf}$) . . . . | 55 | 122 | 4.31 | 0.035 | 0.061 | 0.006 |
| Roof of Lower Kazan substage ($P_2^{kaz_1}$) . . . . . | 40 | 122 | 2.98 | 0.024 | 0.069 | 0.007 |

3. Interpretation of Results. The volume and amount of crumpling of the Upper Carboniferous and Artinskian deposits are about the same. The insignificant difference between the amount of crumpling of the Upper Carboniferous deposits (0.046 km) and that of the Artinskian (0.048 km) seems to be the result of errors made while compiling the structural map. In the overlying horizons there is observed a gradual decrease in the volume and amount of crumpling. Thus, in the roof of the Ufa beds the amount of crumpling is 0.035 km, and in the roof of the underlying Lower Kazan substage, 0.024 km.

An analysis of these values leads to several conclusions. The equal amount of crumpling of the Carboniferous and Artinskian beds is evidence of the fact that the process of crumpling of these deposits began after the formation of the Artinskian deposits. The considerably lesser amount of crumpling of the Ufa deposits shows, on the one hand, that the crumpling of the Carboniferous and Artinskian beds took place in post-Artinskian time, but prior to the formation of the Ufa sediments. On the other hand, it may hence be inferred that the crumpling of strata did not cease during the Ufa and Lower Kazan time.

The author can by no means agree with S. P. Egorov who believes that the process of the uplift of the strata began in the Carboniferous and ended in the post-Artinskian time, after which only an «enveloping of the old tectonic forms» with younger sediments took place.

The author has computed that within the area studied the average thickness of the Ufa deposits is equal to 61 m, and the average thickness of the Lower Kazan deposits, to 69 m, which makes up 130 m (see table). It would hardly be justifiable to expect that such a great thickness of deposits would have repeated, one stratum after another, the «old tectonic forms», the angles of dip of which do not exceed 2° and in most cases are about 1°. A complete levelling of the bottom would have been attained within the first fifty meters of the Ufa deposits.

It is quite obvious that here we have to do with a process gradually dying out in time, going on against the background of a general regional subsidence of the Earth's crust. The latter process is reflected by the formation of the thicknesses of the deposits (1).

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*MINERALOGY*

# NATIVE IRON IN THE KOMI ASSR

By I. A. PREOBRAZHENSKY

*(Communicated by W. A. Obruchev, Member of the Academy, 15.VII.1943)*

In the specimens of rocks from the Lopyuss deposit of siderite ores on the Sysol river, south of Syktyvkar, collected by V. S. Myasnikov, the author found small grains of native iron. The specimens were taken from test-pit No. 155, partly from test-pit No. 151, in the Davpon area of the deposit. The native iron is found throughout the section of the test-pit, from morainic deposits underlying Jurassic siderite-bearing clays (Fig. 1). The iron grains are of a varied nature:

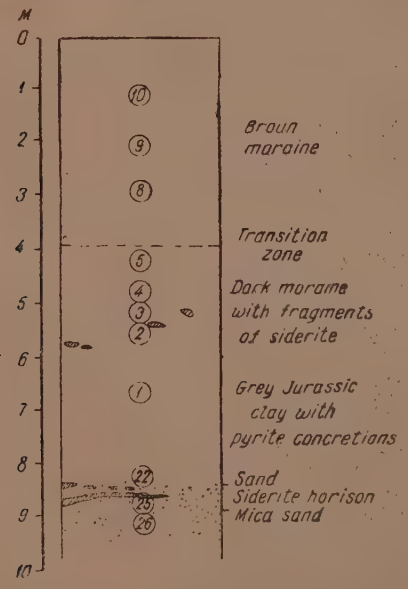


Fig. 1. Section through test-pit No. 155. Iron: *1*, grains with a grey clayey mineral, in brown ironstone with magnetite and sulphide (?). Readily dissolve in HCl and reduce Cu. *2*, flakes, some dissolve in HCl and reduce Cu, others are not dissolved or sparingly dissolved in HCl and do not reduce copper. *3*, lustrous lamellae: do not reduce Cu, not dissolved in HCl. *4*, lamellae, dissolved in HCl; residue—chlorite (?). *5*, like No.*4*. *8*, like No.*10* (see below); concretions with magnetite, grains of sulphide. *9*, like No.*3*. *10*, porous, easily oxidized, and reduce Cu, in brown ironstone, around vegetable fibres. *22*, porous, foliated. *25*, flakes with magnetite. *26*, like No.*25*

1. Irregular in shape, acute-angular, with a hardly perceptible striation on the surface, sometimes with longitudinal striae and outgrowths.

2. Porous, easily oxidized in the air after a dissolution of their surrounding coating of brown iron oxides; easily reduce copper from a blue copperas solution.

3. Grains with a laminar structure; when pressed with a needle, they fall into thin laminae from 0.25 mm and less down to thousandth fractions of a millimeter in size. The latter, remaining suspended in water, are orientated under the action of a magnet. Sometimes on the iron laminae there are found on one side grains of magnetite and brown iron-ore. In other cases the iron laminae and magnetite

grains are found on lamellae of a very light brownish-green mica-like mineral, probably belonging to the chlorite group, showing no double refraction perpendicular to the cleavage, with a refractive index varying along the edges of the lamella from 1.571 and over 1.653. Of the laminar grains some are readily soluble in HCl and reduce copper, while others are not dissolved at all or sparingly dissolved in HCl and do not reduce copper, being as flexible and lustrous as the former ones.

Of the five grains sampled, three yielded a weak reaction for Ni with dimethylglyoxime.

In the brown morainic clay and in the grey Jurassic clay containing concretions of siderite, in the magnetic fraction there were found small grains of brown

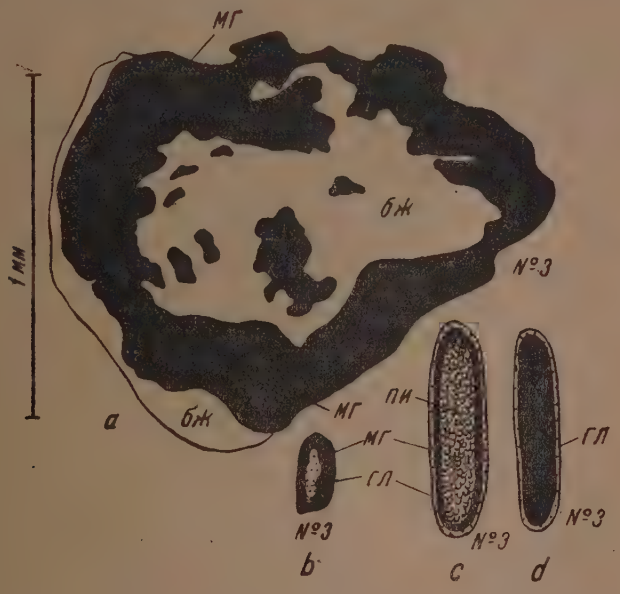


Fig. 2. Grains with brown ironstone (*бэс*), magnetite (*мг*), pyrite (*пи*) and clayey matter (*гл*)

iron-ore of various shape, formed, as it seemed, as incrustations around vegetable fibres, not infrequently projecting on the outside of the grains. In order to investigate these grains they were enclosed in a drop of fir balsam on an object-glass and then gradually ground off; drawing of the sections made it possible to establish the shape of the grains of the minerals occurring in these grains (Fig. 2, *b*). Inside brown iron-ore grains there were found: numerous rounded grains of magnetite, irregular-shaped grains of native iron, sometimes trough-shaped, rounded; curved grains of a mineral with a metallic lustre, yellowish; according to I. N. Chirkov, it is chalcopyrite; sometimes it has grown together with sphalerite; sphalerite occurs in detached grains with a fine emulsion-like dissemination of chalcopyrite, a vegetable tissue with parallel fibres. Trough-shaped iron grains have sometimes grown together with magnetite. In the magnetic fraction of the morainic and Jurassic clays rounded grey grains have also been found; some of them consist of a coating of magnetite around the grain of brown iron-ore (Fig. 2, *a*) like the coatings of titaniferous magnetite in the grains from Timan sandstones ([1]); others, of a coating of magnetite around a clayey core (Fig. 2, *b*); still others, of a clayey coating and a magnetite core (Fig. 2, *c*); others still, of a very fine clayey coating followed by a magnetite one, 0.02 mm thick, and a pyrite core (Fig. 2, *d*). In the clayey coating there are colourless lamellae with a slight birefringence, with $N \simeq 1.562$, and brownish ones with $N > 1.571$, soluble in diluted $H_2SO_4$. It is pos-

sible that the pyrite, magnetite and brown iron-ore are genetically related, and the scheme of formation of the native iron closely resembles the one given by Eitel for the basalts from Bühl near Kassel (²), but instead of pyrrhotine we have pyrite, brown iron-ore being inserted: pyrite—brown iron-ore—magnetite—native iron. The vegetable fibres and clayey minerals in the grains with native iron on the Sysol river show no traces of high temperature influence. The low content or absence of nickel in the grains of iron and its association with vegetable fibres are evidence of its telluric origin and authigenic nature. The reduction of brown iron-ore to magnetite and of magnetite to native iron seems to have taken place under participation or under influence of organic matter, which is indicated by the relation between brown iron of magnetite inside the vegetable remains. The replacement of the wood by metallic iron was pointed out by Bahr, but Stapf considered this iron to be an artificial product formed upon charcoal smelting [after Dölter (²)].

The presence of lamellae of a chlorite-like mineral with laminae of native iron and grains of magnetite grown upon it points to a different mode of formation of native iron, and justifies the assumption that upon reduction processes ferruginous chlorites gave magnetite and native iron, the latter being produced in the form of thin laminae, as a pseudomorph after chlorite.

In morainic clays the following heavy minerals have been found: almandine, andradite, apatite, brown iron-ore, galena (a fresh surface with a metallic lustre), glaucophane (?), disthene, dolomite, native iron, ilmenite, magnetite, pyrite (octahedra, less frequently cubes), hornblende, rutile, siderite (grape-like grains), staurolite, tourmaline, chlorite, zircon, spinel (?), epidote. All of these minerals with the exception of galenite and hornblende, have been found also in the Jurassic deposits, in which augite, biotite, monazite and muskovite have been encountered in addition. An evidence of reduction processes in the morainic clay is furnished by the presence of galenite in fresh crystals with a non-oxidized surface and of grape-like small grains of siderite (Fig. 3, *a*), probably authigenic. Here possibly a process of sideritization was beginning analogous to the one occurring in the Jurassic clay when siderite concretions were formed. In the same clays newly formed crystals of garnet have been found similar to those observed in the sandstones of Timan (³) (Fig. 3, *b*).

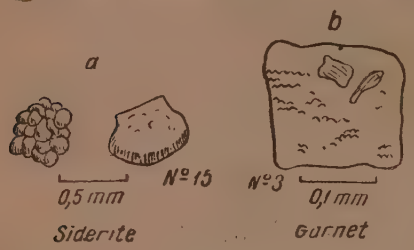

Fig. 3. Grains of garnet and siderite in morainic clay

Native iron was found by the writer in Lower Carboniferous clayey shales. outcrops of which are found along the Kozhim river, a right-hand tributary of the Kos-yu river, and along the Nortnicha-iol, a left-hand tributary of the Kozhim. These shales dip NW 20—40° and carry siderite concretions. In the specimens of shales taken under the concretions, native iron occurs in the grains along with magnetite.

Magnetite forms a kind of coating around the brown iron-ore grains; outside of this coating there are grains of iron about 0.1 mm in size. In the shales over the concretions native iron is closely associated with magnetite, occurring side-by-side with it as thin lamellae about 0.15 mm thick, as it seems, forming a thin coating on the surface of magnetite grains. There are also some grains of iron with indented edges, up to 0.4 mm in size. In the shales under siderite concretions there is a considerably larger amount of iron as brown iron-ore, which is evidence of the existence of oxidation processes in the shale exposures; possibly, a part of the iron produced in the formation of the siderite concretions has already been oxidized.

Middle Devonian quartz sandstones with conglomerate bands exposed in the Pechorskaya Pizhma river, 200 km from the mouth of the Pizhma, contain metallic iron, as do the corresponding quartz conglomerates of North Timan. Iron grains occur as curved wire-like rods about 0.01 mm thick, as sinuous bands up to 0.5 mm

long and up to 0.08 mm wide, and as lamellae, sometimes perforated. The surface is in most cases lustrous, sometimes scarred on the one side, and covered with small tubercles on the other. Upon dissolving a lamella of iron $0.97 \times 0.66$ in size and not over 0.02 mm thick, there was left a yellowish transparent lamina with bluish-green spots of an indefinite shape, with pleochroism: $N_p$ colourless or very light greenish-blue; $N_g$ greenish-blue; $N_p \leqslant 1.569$. It is probably delessite, the iron of which has been reduced to metal. Characteristic of the quartz sandstones of the Pechorskaya Pizhma is the formation of new faces upon the garnets, often entirely covering garnet grains; similar newly formed faces seem to occur upon tourmaline and zircon grains. In the quartz sandstones there occur occasionally bed extrusions and dykes of basalts; their action upon the sandstones is felt only within a small distance. In addition to garnet, delessite, iron, tourmaline and zircon, in the sandstones the following minerals have been found: actinolite, anatase, apatite, brookite, brown iron-ore, disthene, gold, ilmenite, quartz, corundum, xenotime, leucoxene, magnetite, monazite, muscovite, orthite, pennine, pyrite, rutile, staurolite, chlorite, chromite. The Middle Devonian sandstones of the Umba river, a right-hand tributary of the Pizhma, also carry native iron. Native iron of a telluric origin is of no infrequent occurrence. Its deposits on the Sysol and Kozhim add to its distribution over the Russian Platform ([1]). J. A. Makerov found native iron in the region of the Upper Amur in the Far East ([4]). It is probably that upon a more careful examination of the magnetic fraction of black sands or sedimentary rocks in general, the number of native iron occurrences will be still increased.

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*PALAEONTOLOGY*

# *ACERATHERIUM ARALENSE* n. sp.

By A. A. BORISSIAK, Member of the Academy

Among the Old World fossil rhinoceroses which because of the fragmentary condition of their remains mostly defy taxonomic grouping, the *Aceratherium lemanense-tetradactylum* group is more sharply outlined. Up to this time its members were known from the West European Tertiary*. Lately, an Asiatic representative of this group (*Ac. Depereti*) has been described from the Dzhilanchik beds (Lower Miocene) of Turgai steppe (1). The form under description seems to belong to the same group. Its remains, comprising an almost complete skull and fragments of another specimen, were found during the excavations of the Aralian locality (*Corbula helmerseni* beds, Upper Oligocene).

All these forms have in common the skull structure: skull dolichocephalic, nasals very long and narrow, nasal notch deep, orbits shifted forwards, frontal region narrow, rhombic, abruptly tapering forwards (to the region of nasals) and backwards, notch of occipital margin deep, occipital wall low, narrow, fossae below the occipital crest deep, etc. The skull presents only small variations of these features in different forms. In the otic region the post-tympanic process is shifted on to the post-glenoid process. A distinctive peculiarity of the skull under description lies in the strongly developed supraorbital rugosities **.

The lateral nasal notch reaches as far back as the boundary $P^3$—$P^4$; the anterior margin of the orbit lies opposite the front part of $M^2$; infraorbital foramen, at the edge of the nasal notch over $P^4$; hind nasal notch of palate, opposite the middle of $M^2$***.

The most striking feature of the skull described is, however, the pattern of the dentition, *viz.* the premolars. Together with a sub-hypsodont condition of the crown, they display a very slight molarization (the lingual ends of the transverse crests converge, and the deuterocone fuses with the tetartocone, forming the lingual wall of the crown), and a total absence of accessory folds. At the same time they reveal a peculiar specialization, since they bear a third transverse hind wall of the crown. Along with this they fully preserve the common type of the upper premolars of the *Ac. lemanense* group, but one of the tendencies of these teeth, weakly expressed in other forms, attains here the highest development.

In $P^2$ the third crest is the less pronounced: proto- and metaloph join lingually forming the lingual wall, the hind end of which bends hook-like in labial direc-

*Besides the above cited, also *Ac. platyodon* and *Ac. (Diceratherium) asphaltense* are to be referred to this group.

**These rugosities are regarded as a sexual character

***Dimensions: general length of skull, 630 mm; maximum width (in orbital region), 233 mm; occipital condyles, 70×45 mm; length of $P^2$—$M^3$, 26, 32, 38, 40, 50, 61 mm, respectively.

tion; a similar hook is directed lingually towards it from the hind end of the ectoloph; these structures, however, are present only at the base of the crown, and only when the latter is much worn they form a crest or a wall closing the posterior valley. In $P^3$ and $P^4$ this crest is developed on a level with the proto- and metaloph. On the worn surface it consists of two lamellae of enamel (outer one, the cingulum; the inner, wall of the hind valley), between which penetrates the dentine of the mentioned «hooks» of the ectoloph and the lingual wall. The protoloph and the metaloph in all three teeth join by their lingual ends, but while in $P^2$ the lingual end of the metaloph is directed somewhat forwards, in $P^4$ it deviates backwards: the only feature speaking of a greater molarization of $P^4$ as compared with $P^2$, so slight is the molarization of the premolars in the form described. As mentioned above, $P^2$ displays also the least specialization, the least development of the third crest.

The described hook-like processes of the lingual wall and the ectoloph are present in many other members of the *Ac. lemanense* group, too (*e. g.* in *Ac. lemanense* from Auvergne, kept in Jardin des Plantes, Paris, No. 2372; München—

Ulm, 1881, IX, 32 c; *Ac. tetradactylum*, Jardin des Plantes, No. 2380; *Ac. platyodon*, Lyon, *etc.*), but they do not form the hind wall.

At the same time all the elements of the premolar crown of the form described maintain the characteristic traits of the *Ac. lemanense* group: triangular protoloph at the beginning of wearing joined to ectoloph by means of a thin connexion; gradual modelling of the deuterocone from $P^2$ to $P^4$; metaloph in the form of a narrow (thin), slightly undulating lamella of equal thickness throughout its length, etc.

To achieve the characteristic of the premolars of the described form, it remains to note that they have a small parastyle fold and a prominent cingulum on the front, lingual, and hind sides of the crown.

The molars, too, possess the characteristc features of the teeth of *Ac. lemanense*: a rounded antecrochet larger than the cone of the protoloph (protocone) and as well modelled as that. Its dimensions increase down the crown, *i. e.* in the more worn $M^1$ it is larger on the worn crown surface than in $M^2$ and smallest in $M^3$.

Crochet in the described teeth has the form of a small fold; in $M^2$ (less worn than $M^1$) the front margin of the metaloph and the lingual one of the ectoloph form four small sharp folds (scalloped); these folds become shallower down the crown and, finally, fade away (thus, they were present possibly in $M^1$ too, but vanished because of strong wear).

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*ECOLOGY*

# ON THE FOOD RELATIONS OF *EURYGASTER INTEGRICEPS* IN THE HIGHLAND OF WESTERN UZBEKISTAN

By K. V. ARNOLDI

*(Communicated by A. A. Borissiak, Member of the Academy, 1.IV.1943)*

In foreign literature, as well as in Russian papers concerning *Eurygaster integriceps* we find numerous references to the plants serving as food for this bug. Attention has chiefly been given either to cultivated plants, or to weeds infesting the fields and the neighbourhood. This is partly responsible for the fact that the question as to the food relations of this pest has not been discussed on a sufficiently wide scale. Its solution would, however, facilitate general prognosis of the mass propagation of the pest and of their survival at those periods when they suffer numeral depression.

The investigations which were carried out by me at the mountains and foothills in the basin of the Kashka-Darya river enable me to shed more light upon the food relations of *Eurygaster integriceps*, and to answer the question as to the rôle actually played in its biology by the wild vegetation.

As a result of these observations in which I was greatly assisted by V. A. Arnoldi, 92 species belonging* to 18 families of Angiosperms were found to serve as food for both adult bugs and larvae, and also to be used by the insect for oviposition*.

Below is given a list with the respective figures.

Imago feeding on 90 species, inclusive of 41 *Gramineae* and 15 *Compositae*.

Larvae feeding on 25 species, inclusive of 20 *Gramineae* and 3 *Compositae*.

Oviposition observed on 36 species; inclusive of 17 *Gramineae* and 6 *Compositae*.

From these data it may be seen that the adult insect is obviously polyphagous; the females are somewhat less exacting in placing their progeny than the larvae are in the choice of their food. By selecting out of the whole list only those species that are especially preferred by the bug, we obtain the following ratios:

| | | | | | | |
|---|---|---|---|---|---|---|
| Imago feeding on | grasses | 83.3%, | *Compositae*, | 16.7%, | other, | 0 |
| Larvae feeding on | » | 100%, | » | 0 | » | 0 |
| Oviposition on | » | 100%, | » | 0 | » | 0 |

These figures go clearly to bring out the relation of *E. integriceps* with the grasses. If we are to analyse the relation within the fam. *Gramineae*, adhering to its taxonomy as suggested in the «Flora of the USSR», we obtain:

* The vast herbarium (more than 600 species) was studied by the Tashkent botanist A.I. Wwedensky, and his three co-workers W. K. Paziy, Nikiforova and Butkov, as well as by Prof. E. P. Korovin and G. S. Sumnewich, which I wish to mention here with deep gratitude.

| | Imago feeding in % | Larvae feeding in % | Oviposition in % |
|---|---|---|---|
| *Andropogoneae* | 5 | 5 | — |
| *Paniceae* | 2.5 | — | — |
| *Agrostideae* | 25 | 15 | 17.8 |
| *Aveneae* | 10 | 15 | 12.0 |
| *Chlorideae* | 2.5 | — | — |
| *Festuceae* | 27.5 | 25 | 29.2 |
| *Hordeae* | 27.5 | 40 | 41.0 |

These figures stress again the polyphagous behaviour of the imago, as well as the stable preference of larvae for the *Hordeae*, which is at the same time the choice-plant for oviposition.

Selecting the grasses which are the best preferred by the insect, we have:

| | Imago feeding in % | Larvae feeding in % | Oviposition in % |
|---|---|---|---|
| *Andropogoneae* | — | — | — |
| *Paniceae* | — | — | — |
| *Agrostideae* | — | — | — |
| *Aveneae* | 15.4 | 22 | — |
| *Chlorideae* | — | — | — |
| *Festuceae* | 30.7 | 11 | — |
| *Hordeae* | 53.9 | 67 | 100 |

These figures make it possible to estimate the attachment of *Eurygaster integriceps* to the most important forage crops: they give an idea of its diet when feeding on wild vegetation in the highland of Western Uzbekistan. The main preferred plants are the following: among *Hordeae*, the wild barleys *Hordeum spontaneum*, *H. bulbosum*, *H. leporinum*. Next come *Aegilops triuncialis*, *A. squarrosa*, *A. crassa*, and finally *Agropyrum* (*Elytrigia*) *trichophorum*; among the *Festuceae*, *Bromus sterilis*, *B. tectorum*, *B. macrostachys*; among the *Aveneae*, the oats *Avena meridionalis* and *A. Ludoviciana*.

Mass oviposition was observed only on three barley species. But the females are, as a rule, less exacting, and facultative oviposition is observed on many plants besides *Gramineae*.

It is of interest to analyse the attitude of *Eurygaster integriceps* towards various species of *Compositae*. Among these the bugs show preference for the group *Carduinae* upon which oviposition is the most frequently observed. Thus, on May 5—7, near vil. Yakkabag the bugs could be observed to feed in mass on *Carduus pycnocephalus*. More than once they were found to suck at *Cirsium ochrolepideum*, *C. lanceolatum*, less frequently on *Onopordon acanthium*, *O. Olgae*, *Cirsium turkestanicum*. Hatches were found upon *Carduus pycnocephalus*, *Cirsium ochrolepideum*, *C. lanceolatum*.

According to literary data, the bugs were also found to suck on species of *Carduinae*, fam. *Compositae*. Zwölfer believes that the bugs are attracted by the succulence of these plants. They renew on them their water reserves consumed during the hot season, which is necessary for a normal functioning of their salivary glands.

D. M. Fedotov (1) has proved that we are faced here with real feeding: the contents of the mid division of the intestine consists of a typical dark-brown mass instead of the green one it is found to contain in bugs feeding on fresh grasses. Besides, the bugs were observed to feed upon *Carduus* and *Cirsium* also at earlier stages of the development of vegetation, which clearly points out their preference for these plants. Webster reports that in Irak and Syria the bugs use to lay their eggs mostly on thick leaves of *Compositae*, thus preserving the eggs from heat and wind.

Under our conditions oviposition is observed to take place on *Carduus* occasionally and not as a rule: during those very days of May (5—7), when huge numbers

of bugs were feeding on *C. pycnocephalus*, oviposition proceeded quite near-by, on wild grasses, especially on *Hordeum leporinum*.

Among phytophagous insects the relation with a very restricted assortment of plants, usually belonging to closely related species, is a well-known phenomenon. There are cases, however, which may partly be explained by the chemistry of the plants, but mostly remain obscure, when the insect chooses for its supplementary diet some plants of entirely different taxonomical groups. This seems to take place in the case of *Eurygaster integriceps*.

It is practically important definitely to know, to what extent wild plants or weeds are able to counter-attract the bugs from the crops, and whether they really prefer wild species to cultivated cereals. N. I. Kosobutzky (Samarkand) and A. A. Peredelsky (Kashka-Darya) answer this question in the affirmative. In fact, I was brought by my own experience to think that many wild grasses, *viz.* barleys, *Aegilops*, oats, brooms, prove to be more densely populated by *Eurygaster integriceps* and the oviposition of this insect on them to be more abundant.

This preference is often dependent on the respective state and development stages of the wild and cultivated species. The bugs prefer fresh plants of dense standing, beginning with the earing stage and until milk and wax ripeness. However, when the wild and cultivated plants available happen to be at the same stage, their obvious preference for the wild ones, especially for *Hordeum spontaneum* and *H. bulbosum*, is beyond any doubt.

Quite apart among the plants fed upon by *E. integriceps* stands *Agropyrum trichophorum*. The vegetative organs of this relatively coarse, dry grass are less attractive for the bugs than the tender and succulent barleys and oats. But the couch-grass develops later than the spring ephemeres and ephemeroids, among which the most preferred species belong. In June, when these grow yellow and dry, *A. trichophorum* is quite green still and is even not quite ripe yet. This circumstance makes it then more attractive for *Eurygaster integriceps*.

It has been shown by direct observation, moreover, that the reproductive organs of this grass, in particular its ripening seeds, offer abundant food for adult bugs and guarantee the development of the larvae. From a comparison of larvae according to age (records made during summer in the mountains) it may be seen that the development of those feeding on grain-crops is behind as compared to that of the larvae sucking on ears of couch-grass. For example, on July 12—13, in the region of Kok-Bulak—Kizil-Mazar, per every 10 imagines there were found on wheat 4 larvae of the V instar, 2 larvae of the IV, whereas on *Agropyrum trichophorum* to each 10 imagines there corresponded 3 larvae of the V instar, while younger specimens were entirely lacking.

The results of our observations remove all doubt concerning the great importance of *A. trichophorum* for the mass development of the mountain *Eurygaster integriceps*. And this in spite of the fact that, as pointed out above, this grass at its earlier stages of development is less attractive for the bugs than wild barleys and cultivated cereals. Several reasons account for its importance: 1) low rate of vegetation and a very long period of earing and ripening, and 2) high drought-resistance, owing to which the couch-grass looks rather fresh throughout the summer in the mountains of Western Uzbekistan.

Taking into account that *A. trichophorum* is a most common plant all over a mountain belt lying about 1300 to 2000 m above the sea level, and that this belt embraces the places of the normal and continuous development of *E. integriceps* population outside the conditions of its mass propagation, i. e. its reservation, the paramount importance of the relation between the pest and this plant becomes quite evident.

The knowledge of the relations between *E. integriceps* and the plants it feeds upon have direct bearing on agricultural practice.

It stands to reason that the wild vegetation plays a very important part in the biology of *E. integriceps* in all the regions of the Western Uzbekistan, irrespective of the agricultural conditions prevailing there. It is especially important in

the mountainous regions which offer almost unrestricted possibilities of existence and of surviving during the unfavourable periods.

In planning an efficient system of controlling the pest, an important place should belong to keeping the crops uncontaminated. The wild plants on which the pest are likely to feed should be destroyed both on the field and around the crops. The wild grasses preferred by the pest are especially dangerous, because they do not develop all at the same time and rate; owing to this, both egg-laying females and feeding larvae may attack the plants at the most favourable stage of their development, from earing to the various stages of ripeness of seed. Optimal conditions for the development and numeral growth of the pest are thus available.

An acquaintance with the plants preferred is also important when planning the so-called «provocational» crops which are aimed to counter-attract great numbers of bugs, which can thus be destroyed on these crops. Instead of cultivated cereals wild early species may serve for this purpose: in the first place *Hordeum spontaneum*, as well as brooms and wild wheat *Aegilops*. On the other hand, the success of such «provocation» crops is anything but promising in a region where extensive grain fields are surrounded with wild vegetation consisting of such plants as are known to be preferred by the pest.

A procedure to be applied for destroying the wilds plants fed upon by *E. integriceps* is: 1) a repeated weeding of the crops, and 2) a cutting of the wild grasses, especially directly after mass oviposition.

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*ECOLOGY*

# COLD-RESISTANCE OF THE AMUR WILD CARP *CYPRINUS CARPIO VIRIDIVIOLACEUS* (UNDER CONDITIONS PREVALENT IN THE CENTRAL AND NORTHERN ZONES OF THE EUROPEAN USSR)

By V. S. KIRPICHNIKOV

*(Communicated by I. I. Schmalhausen, Member of the Academy, 26. IX.1943)*

Svetovidov ([1]) analysing several systematic characteristics of the wild carp (number of soft rays in the dorsal fin, number of scales along the lateral line, and number of gill-rakers) isolated the wild carp of the Amur river from the group of other wild carps of Europe and Central Asia, as an independent subspecies. The validity of this classification has been confirmed by further systematical investigations ([1,2]).

This subspecies, inhabiting the Amur river and several related lakes, as well as many rivers of China, has been cut off from the European group of wild carps since the last ice age. Berg ([1, 3]) states that during the Tertiary, Siberia was inhabited by a more thermophilous fauna which perished during glaciation; this explains the resemblance between the Amur fauna and the fauna of Europe. The wild carp of Europe and the wild carp of the Far East belong to a single species dissociated by glaciation. According to Nikolsky ([4]) the wild carp penetrated again into Central Asia from the West, through the Ponto-Caspian Aral lowland which was submerged during the Quaternary.

The climate of the basin of the Amur is severe, with cold, snowless winters, predominant northern and north-western winds and warm summers. The greatest part of the yearly atmospheric precipitation corresponds to the summer period. According to Pravdin ([5]), the Amur river and the related lakes are characterized by frequent floods (up to 4) in summer, relatively low water-temperatures and a poor food supply. This, according to Probatov ([6]), accounts for the slow growth rate of the Amur fishes, including the wild carp.

The Chinese wild carp, which belongs to the same subspecies, inhabits regions characterized by a warm winter (the wild carp, as a rule, belongs to warm-water fishes). Thus, ecologically, the Chinese and the Far-eastern carps are more remote from each other than some forms of the European subspecies from the Far-eastern carp. There are no precise data in literature bearing on these differences. We have, however, some interesting material concerning the comparative adaptation to high and low temperatures and the thermal optimum of the European domesticated carp and a local form from Netherlands India. To judge from data available this form descends from *C. carpio viridiviolaceus*.

Bushkiel in a series of experiments noticed considerable differences in the thermal adaptation of these groups of the species *C. carpio* L., isolated spatially and climatically. The curve of optimum growth and metabolism of the Indo-Chinese carp shows a notable shift towards higher temperatures; hence we may expect also to find differences in the thermal adaptation of the Chinese Indo-Malayan group of carps and the carp of the Amur basin with its severe winters.

In 1936, the wild Amur carp was, at my suggestion, introduced in the European

part of the USSR to be acclimatized in Moscow and Kursk districts. In 1939 and 1940 it was shipped in special cars and by airplanes to the Nikolsky state fish farm. The region where the Nikolsky farm is situated, is in respect to climate one of the severest of the Leningrad district.

A detailed comparative study of the Amur carp, and the previously acclimatized Volgo-Caspian and Taparavan wild carps (lake Taparavan, Georgia), as well as domesticated carps of the «scattered» type (7) disclosed the high qualities of the Amur carp, reared in the northern waters, in respect to exterior, growth and condition. Most interesting results have been obtained in investigations of cold-resistance of the Amur carp, carried out in the winters 1939/40 and 1940/41.

Yearlings of the Amur carp supported well their first winter at the Nikolsky farm (Table 1), though it was exceptionally severe. The mortality in winter was 11 per cent as compared to almost 100 per cent in control carps (8). Even in intergeneric hybrids: *Cyprinus carpio* L. × *Carassius carassius* L. and *Cyprinus carpio* L. × *Carasstus auratus gibelio* Bloch. the mortality in this winter amounted to about 50 per cent (9).

Table 1

Wintering Losses of Yearlings of the Domesticated Carp, Hybrids between Taparavan and Amur Wild Carps (Nikolsky fish farm)

| Pond | Group of fish | Stocking | | Catch | | % of loss |
|---|---|---|---|---|---|---|
| | | number | mean weight in g | number | mean weight in g | |
| | | 1939—1940 | | | | |
| Trout-pond No. 3 | Amur carp | 107 | 27.3 | 95 | 25.6 | 11.2 |
| | Taparavan carp | 865 | 35.7 | 63 | 31.3 | 92.7 |
| | Domest. carp | 189 | 24.9 | 0 | — | 100.0 |
| Trout-pond No. 2 | Domest. carp | 1000 | 24.2 | 1 | 20.0 | 99.9 |
| | Hybrids[1] | 844 | 36.4 | 212 | 43.4 | 74.9 |
| Other wintering ponds | Domest. carp | 73441 | 10—60 | 13 | about 30 | 99.98 |
| | Hybrids[1] | 90866 | 10—100 | 522 | » 80 | 99.43 |
| | Hybrid wild carps[2] | 976 | about 40 | 1 | » 50 | 99.90 |
| | Carp-crucian carp | 250 | » 25 | 127 | » 25 | 49.20 |
| | | 1940—1941 | | | | |
| Trout-pond No. 1, 2, 3, 4 and 5 | Amur carp | 4295 | 32.3 | 3722 | from 27.5 to 30.5 | 13.34 |
| | Taparavan carp | about 70 | — | 7 | — | about 90.0 |
| | Domest. carps and hybrids | 6238 | from 10 to 30 | 0 | — | 100.0 |
| | Carp-crucian carp | 43 | about 25 | 8 | about 25 | 81.4 |
| Carp-pond No. 4 | Amur carp | 1000 | 32.3 | 844 | 28.0 | 15.6 |
| | Domest. carp | 11000 | about 10 | 0 | — | 100.0 |
| | Domest. carp | 1250 | » 30 | 0 | — | 100.0 |
| Feeding pond No. 4[3] | Amur carp | 250 | 32.3 | 174 | — | 30.4 |
| | Domest. carp | 1000 | about 40 | 4 | — | 99.6 |
| Other wintering ponds | Domest. carp | 45620 | 10—20 | 0 | — | 100.0 |
| | Domest. carp | 29243 | 20—80 | 0 | — | 100.0 |
| | Hybrids | 2381 | 40—50 | 575 | 40—50 | <75.0 |
| | Hybrids | 3681 | 10—15 | 0 | — | 100.0 |
| | Hybrids unidentified | — | — | 677[4] | 40—80 | — |

[1] To hybrids is referred the $F_1$ and $F_2$ of the cross between the Taparavan wild carp with the domesticated carp.

[2] To hybrid wild carp is referred the progeny of the cross between the Taparavan and the Volga-Caspian wild carps.

[3] The fish was planted under ice later than the others.

[4] From 1252 individuals caught in the spring only 575 could be identified. The remaining 677 are domesticated carps or hybrids.

The results of the second winter were similar in the main: the total loss of the Amur carp at the Nikolsky farm was 14 per cent (data for individual ponds, see Table 1); that of the control material exceeded 99. At the Valdaisk fish farm where several thousands of young Amur carp were introduced in autumn 1940 (age group 0+), the results of the first winter were less illustrative (Table 2).

Table 2

Wintering Loss of 1-year-old Domesticated Carp and Amur Wild Carp (Valdaisk fish farm)

| Branch of the farm | Pond | Group of fish | Stocking, number | Catch, number | % of loss |
|---|---|---|---|---|---|
| Yajelbitzy | Rearing pond № 4 | Amur carp | 2099 | 1757 | 16.3 |
| | | Domest. carp | 38000 | 1844 | 95.1 |
| Zavyssochje* | Rearing pond № 2 | Amur carp | 700 | 173 | 75.3 |
| | | Domest. carp | 12800 | 350 | 97.3 |
| Ustoronje* | Rearing pond № 2 | Amur carp | 1526 | 208 | 86.4 |
| | | Domest. carp | 13000 | 9220 | 29.1 |

* The Amur carps were frost bitten and severely bruised during their transfer to Zavyssochje and Ustoronje.

Only at the one of the three branches of the Valdaisk farm Yajelbitzy, there were obtained figures as eloquent as those of the Nikolsky farm (Table 2). At Zavyssochje the loss of wild carp, though much lower than that of the controls, was still considerable, while in Ustoronje the loss of wild carp even greatly surpassed the loss of the domesticated carp. However, these results are determined by mode of conveyance rather than by differences in cold-resistance of the forms investigated. Thus, to the Nikolsky and Yajelbitzy farms the Amur carp was conveyed in autocars and arrived in good condition, whereas to Zavyssochje and especially to Ustoronje they were transferred by horse on canvas and were badly bruised and frost bitten (the temperature of the air being —5°C). 400 young carps perished during the journey, and a considerable part died evidently directly upon their transfer to the wintering ponds.

Two- and three-year-old Amur carps proved to be highly cold-resistant: all of them survived, whereas other wild and domesticated carps of the same age gave a loss ranging from 10 to 50 per cent.

We have no conclusive data on the relative cold-resistance of the Amur and the Volga-Caspian carp. The only thing we know is that the Amur carp is much superior to the Taparavan carp in respect to cold-resistance*. However, some indications to the advantages of the Amur carp as compared with the Volga-Caspian are furnished by data on the mortality of hybrids Volga-Caspian × Taparavan carp, as well as by the results of experiments with the Volga-Caspian carp under conditions prevailing in the Moscow district.

In 1940/41 the Amur carp yearlings and 1-year-olds, as well as the controls, had very low condition coefficients (effect of the cold summer 1940) as compared with the average coefficients for a series of years (Table 3). Nearly all domesticated carps perished (even individuals in the highest condition did not survive the rigours of the winter). The wild carp survived everywhere, and a distinct correlation was observed between the loss of weight during the winter period, the vernal value of the coefficient of condition and the mortality**.

Among other wild carps the Amur carp is characterized by the highest values of the coefficient of condition (Table 3). We suppose that this primarily accounts

* It should be noted that the qualities of the Taparavan carp are greatly deteriorated by acclimatization ([10]).

** The coefficient of condition is computed by the formula $K=\frac{100\ g}{l^3}$, where $g$ is weight, $l$ is body-length, measured from the tip of the snout to the end of the scale-integument.

Table 3

Coefficients of Condition of Young Amur Carp

a) Mean coefficients for several years

| Group of fish | Amur carp | Volga-Caspian carp | Taparavan carp | Domesticated carp (controls) |
|---|---|---|---|---|
| $M_m \pm m$ | 2.866±0.017 | 2.676±0.021 | 2.638±0.031 | 3.258±0.044 |

b) Correlation between loss of weight and condition and percentage of loss of the Amur carp in the winter 1940/41

| Pond | Coefficient of condition | | Average weight at catching in g | Loss in average weight in g | % of loss |
|---|---|---|---|---|---|
| | at stocking | at catching | | | |
| Trout-pond № 4 | 2.71 | 2.48 | 30.5 | 1.8 | 10.2 |
| Trout-pond № 1 | » | 2.37 | 29.5 | 2.8 | 11.5 |
| Carp-pond № 4 | » | 2.35 | 28.0 | 4.3 | 15.6 |
| Trout-pond № 5 | » | 2.34 | 29.0 | 3.3 | 15.7 |
| Trout-pond № 2 | » | 2.27 | 27.5 | 4.8 | 24.6 |
| Trout-pond № 3 | » | 2.25 | 28.6 | 3.7 | 13.8 |
| Feeding-pond № 4 | » | 2.40 | — | — | 30.4* |
| Control carp** | 2.93 | — | — | — | 100.0 |

* In autumn the fish was planted under ice, after the stocking of other ponds.
** Only the autumn value of the coefficient of condition is given, all the carps having perished.

for its high cold-resistance (great reserves for the period of long winter fast). Sigov ([11]) showed the existence of a relation between the condition of young planted into wintering ponds and the wintering results. Besides the great reserves of nutrient matter, a great part is played by the lowered oxygen consumption at low temperatures (from 1 to—10°C), as established by A. V. Rosova and the author. Experiments on respiration intensity were carried out in closed glass jars filled with water. The chief purpose of these experiments was to determine the respiration intensity in 1-year-old wild and domesticated carps at temperatures prevalent in wintering ponds (unpublished data).

Acclimatization work with wild carp without previous experimental investigation should be strictly forbidden.

Some problems of the theory of species-formation and interspecific divergence, on which our data on cold-resistance may have some bearing, are discussed elsewhere ([12]).

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*EXPERIMENTAL MORPHOLOGY*

# PRINCIPLES OF AND METHOD FOR COMPENSATING FOR NERVE DEFICIENCY BY GRAFTING PREPARED NERVOUS TISSUE

By ARNOLD SCHABADASCH

*(Communicated by N. N. Burdenko, Member of the Academy, 1.IV.1943)*

The problem of the renewal of a lost tissue in the case of a lesion of the peripheral nerve is of great theoretical and practical interest. In case of a great gap the tendency to unite the central and the peripheral stumps with the help of a graft is natural and logically grounded, if the central mechanisms of regeneration are not damaged. The idea of grafts into the peripheral nervous system has more than ones been recorded in literature. Number of suggestions—such as those by Nageotte, Gosset and Bertrand, Anokhin and others—have been discarded after clinical and experimental examination (Burdenko, Sanders and Young, *etc.*).

What is then the cause of the failure of homo- and heterografts by a fresh, dead or a preserved nerve? Experiments show that natural (unprepared) nerve tissue, being grafted, is resorbed before the regenerated central axons reach the peripheral end of the injured nerve trunk. Consequently, it is necessary to preserve the tissue which is to be transplanted, *i. e.* the graft must be fixed. Therefore, the methods of Nageotte, of Gosset and Bertrand and of others are a step foreward, for their grafts remain unresorbed during a long time in the organism of the host; they serve as a mechanical support, as a kind of «bridge» or a «false-work» for the new formed axons. But these methods have two essential shortcomings: first, the regenerated axons are running only on the surface of the graft, whose core is being resorbed very slowly; thus, the quantity of newly formed nerve fibres is not sufficient for the physiological function. And, secondly, even if the regeneration begins, it is soon arrested because of chronical irritative inflammation.

My method does not arise from some successful empirical observation, but is based upon a long series of experimental and histological investigations which have brought out the conditions that stimulate or impede the restoration process. My experiments have shown three cardinal factors to underly the secondary neurotization of the graft itself and, consequently, of the united stumps of a traumatized nerve: 1) stability of auxiliary fibrillar structure during a time sufficient for mass proliferation of mesenchymal and neuroglial complexes and for the associated growth of the central axons; 2) the elimination from the graft of all hindering influences which are mainly due to the sterols and some other lipoids of the myelinated sheats; these chemical agents limite considerably the restoration process; 3) intensification of the local metabolic level and of the mitotic activity of symbiotic cells, which is favourable for the regeneration and growth of axons. I have shown that these conditions are realized by creating a depot of carbohydrates and magnesial salt at the first stage which is followed by a moderate aseptical inflammatory process, the latter being a consequence of a graduated resorption of our graft.

We do not meet such a combination of the required qualities in the fresh or dead natural nerve tissue; they arise as a result of an artificial treatment which, as it is clear to every competent student, cannot be reduced to a mere immersion into alcohol or formol.

The principle of my method of preparing a nerve graft consists in a gradual step-by-step «remaking» of a human or animal nerve (taken from young subjects). New histological and chemical qualities of the graft arise as a result of this technique of graduated treatment. A fresh graft (no more than 2 hours after death) is immersed in succession: a) in 70° alcohol, 48 hours; in 96° alcohol, 24 hours; b) in a mixture of 3 parts of ether and 1 part of 96° alcohol for 120 hours, for extraction of some of the lipoids; and c) is kept in a definite solution of 10 per cent glucose and magnesium glycerophosphate (or chloride), 0.3 per cent. All these procedures are carried out under strictly aseptic conditions.

As a result of this special preparation the nerve graft assumes new and definite physical, chemical and biological qualities: the first is characterized by the presence of many «microchannels» throughout the substance, and at the same time by a longitudinal orientation of the fibrillar structures which are being slowly and gradually resorbed after the transplantation; the second is represented by the absence of sterols and some other lipoids and by the presence of a depot of carbohydrate and of magnesial salt; the third is demonstrated by the peculiarities of the reactive process in the region of the graft after the operation.

I have examined all preparations microscopically and have watched all the stages of regeneration. The histological picture depends on the time elapsed after grafting. The section of the nerve (sciatic nerve) above the graft's level displays a usual normal structure of a myelinated nerve with a predominance of thick axons. The cuts through the central part of the graft itself show at the period of a good restoration (2—3 months for a dog) numerous bundles of unmyelinated, newly formed fibres which run in their majority directly and by short ways to the degenerated stump of the injured nerve (silver impregnation). In the area of the junction of the grafted segment with the peripheral nerve we do not see any trace of neuron: it can be stated that the numerous unmyelinated nerve bundles penetrate into the bands of Büngner without any obstacles; they serve as a good basis for the functional success of my grafting method. The myelinization of the newly formed fibres occurs in the same way as in the case of an ordinary suture of a nerve.

The renewal of a lost portion of a nerve by way of centrifugal regeneration requires, first, that the central parts of the neuron be sufficiently active for the enormous synthetical work, and, secondly, that the local proliferation of axons and mesenchymal or glial complexes be congruent and well-timed. Histologic controls show that the graft becomes vascularized and is later gradually resorbed by the host's organism. Secondary neurotization begins from the first week and proceeds rapidly. The regeneration and the proliferation of the symbiotic tissues is directed by the «microchannels of growth» previously prepared in the graft by our treatment; we see therefore that the newly formed axons pervade the whole core mass of the graft.

It is necessary to emphasize briefly some theoretical points. The tissue elements of the graft itself are deprived of living qualities. The rôle of the graft is but a helping one. But the degree of the subsidiary participation of the graft in the restoration process may be very efficient; it depends on the physical, chemical and biological qualities of the transplanted tissue. In my cases I observed a very stimulating biological process to take place after operation. Any nerve graft, inclusive of ours, is a foreign body; it must therefore be the source of an aseptic inflammation which may limit the regeneration, as many writers believe. However, the qualitative peculiarities of a graft can make even the inflammatory reactions favourable for our purposes. Namely, the denaturation of the protein compounds of the graft only by dehydration, the elimination of sterols, the presence of carbohydrates and of magnesial salt, all these lead in our cases to a predominance of proliferative processes. As a result of gradual but definitive resorption of our graft, this region

is characterized by a high local metabolic level and abundant mitoses: this is the cause of a good regeneration of axons induced by my grafts. Therefore I have coined for my method the name of «protective plastic»: it unites the microphysical auxiliary factors with the stimulating biological process.

The operation was also performed on men (17 cases). The term is too short to form any definitive conclusion. In all cases the operation proceeds without any complication. The grafting does not result in any pain symptoms or trophical disorder, and those which existed previously are now removed. The clinical symptoms are multiform, for the graft stimulates probably the vicarious potencies of the whole nervous system. The postoperative treatment by longitudinal galvanization, by injection of $B_1$ vitamin and of glucose+insulin is necessary and very effective: in 3 cases the restoration of muscular movements took place after 7 months (transplantation in the radial and tibial nerve). So far as the experimental results are well grounded and the period required for a complete restoration in man is too long, the graft can safely enough be practised even at present in case of such war lesions where the neuro-surgeon fails.

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*HELMINTHOLOGY*

# CONTRIBUTION TO THE STUDY OF THE DEVELOPMENT OF *THYSANIEZIA OVILLA* (RIVOLTA, 1878), A TAPEWORM PARASITIC OF RUMINANTS

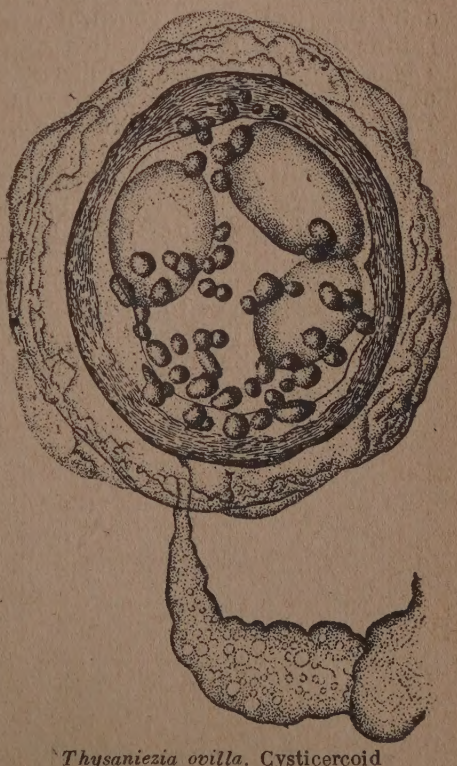
By V. A. POTEMKINA

*(Communicated by K. I. Skrjabin, Member of the Academy, 18.IV.1943)*

It is known that the developmental cycle of the tapeworm *Thysaniezia ovilla* (Rivolta, 1878) Skrjabin, 1926, until recently remained undeciphered. Yet, this parasite is widely distributed, inflicting heavy economic losses to animal breeding and leading in some cases to ruinous outbreaks of helminthosis, and no prophylactic measures can be taken unless its biology is thoroughly known.

By analogy with the rest of anoplocephalids it seemed theoretically plausible to consider *Thysaniezia ovilla* as a biohelminth, using as intermediate hosts small soil-ticks, oribatids. It is in this direction that our investigation was launched.

Within the period from May, 1940, till July, 1941, we infested with eggs of *Thysaniezia ovilla* about 14 000 ticks belonging to the group *Oribatei*. More than 3000 of them were subjected to dissection. The latter was practised at various terms, so that we were able to record all the developmental stages of *Th. ovilla*, from the oncosphere and up to the cysticercoid, inclusively.



*Thysaniezia ovilla*. Cysticercoid

48—50 hours upon the infection the body cavities of the ticks *Scheloribates laevigatus* were found to contain mobile oncospheres, 0.015—0.018 mm in diameter. Towards the 15th day they increased to 0.026 mm, and towards the 20—25th up to 0.028—0.029 mm. In the course of their subsequent development the larvae became spherical and immobile; they consisted of numerous similar cells and measured about 0.048 × 0.050 mm across. The stage described has been recorded on the 30th day upon infection of the ticks. The development of the larvae proceeded at a temperature of 17—19° C. The spherical stage was followed by that of the

«stretched larva», i0.210 mm in length, the maximum width being 0.077 mm. The body of the larva is now filled with a finely granular substance, the configuration of the suckers is detectable at the swollen part. Calcareous bodies present. The larva thus described was observed by us 70 days upon infection.

The stage of the «segmented larva» was revealed 80—90 days after the ticks had been infested. The anterior, wider part was 0.220 mm long, against a maximum width of 0.180 mm. Four suckers and a group of calcareous bodies observable; the medium part (capsule) oval in shape, $0.10 \times 0.77$ mm across.

After some 80—90 days of keeping at 26° C, and after 120—140 days at a temperature of 17—19° C, the ticks *Sch. laevigatus* were found to contain cysticercoids with underdeveloped scolexes occupying nearly the whole cavity of the cyst. The calcareous corpuscles were now located between the suckers and the cyst-wall. The cysticercoid measured $0.20 \times 0.17$ mm across. In the course of our further observation we succeeded in recording the development of the scolex, the membranes became more solid, and the size of the cysticercoid diminished correspondingly, so that in ticks of the family *Ceratozetidae* it did not exceed 0.13—0.15 mm.

Invasional cysticercoids were observed in ticks *Scheloribates laevigatus* on the 130—150th day after the moment they had been infested.

On October 16, 1941, two lambs at the age of 3 days were given ticks *Sch. laevigatus* and *Sch. latipis* with 140-day-old cysticercoids of *Thysaniezia ovilla*. Lamb No. 1 received 40 ticks (40 cysticercoids); lamb No. 2, 30 ticks (40 cysticercoids). The infested ticks were given in all cases in gelatine capsules, after the lambs had been withheld from food. During the experiment the lambs were fed with cow milk and kept in a stall. Since the 15th day the experimental lambs were daily subjected to a coprological examination according to Füllenborn's method. During 10 days of examination we failed to detect either eggs, or segments of *Thysaniezia ovilla*. Upon the dissection, which took place on November 12, *i. e.* at the 25th day, we found in the small intestine of lamb No. 1 two individuals of *Thysaniezia ovilla*, and in lamb No. 2, one individual. The parasites were not sex-mature.

As a result of our tests it has been established that the development of *Thysaniezia ovilla* proceeds under a participation of intermediary hosts, and these are soil ticks of the group *Oribatei*, fam. *Ceratozetidae*: *Scheloribates laevigatus* and *Sch. latipis*.

The development of *Thysaniezia ovilla* larvae in the body cavity of the tick from the oncosphere to an invasional cysticercoid takes from 120 to 160 days.

The species of the ticks used for the experiments described have been determined by Prof. A. A. Zakhvatkin, to whom our thanks are due.

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